ENVIRONMENTAL
INFORMATION
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December 4, 2014

Fed Ex Tracking No. 7720 8808 5061

Michael Davidson
Bureau of Air Permits - DAPC
Illinois Environmental Protection Agency
1021 North Grand Avenue East
Springfield, Illinois 62702

RE: **Advanced Disposal Services – Zion Landfill**
Source ID No. 097200AAV; CAAPP Permit No. 97030064
Additional Information Submittal for CAAPP Renewal Application – Updated Landfill Gas Collection and Control System Design Plan

Dear Mr. Davidson:

On behalf of the Advanced Disposal Services – Zion Landfill (ADS-Zion Landfill) located in Zion, Illinois, enclosed please find one (1) copy of an updated Landfill Gas Collection and Control System Design Plan for the facility. The plan has been certified by a registered professional engineer in the State of Illinois. Also included is a 505-CAAPP form signed by the facility's Responsible Official.

The Illinois EPA issued an air construction permit approving an expansion to the facility on October 30, 2014 (No. 12070062), which will require a change to the current gas collection system design. Additionally, the IEPA issued an email request on October 23, 2014 requesting additional information for the upcoming CAAPP renewal permit, including an updated design plan. This document fulfills both requirements.

If you have any questions regarding this submittal, please contact me at 616-891-2592 or Jim Lewis of Advanced Disposal Services at (847) 599-5910.

Sincerely,

Environmental Information Logistics, LLC

Laura L. Niemann

Laura L. Niemann, P.E.
Project Engineer

Cc: Tim Curry, Advanced (e-copy)
Randy Frank, Advanced (e-copy)
Jim Lewis, ADS-Zion Landfill
City Clerk, City of Zion

Attachment

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY DIVISION OF AIR POLLUTION CONTROL -- PERMIT SECTION P.O. BOX 19506 SPRINGFIELD, ILLINOIS 62794-9506	**FOR APPLICANT'S USE** Revision #: ________________ Date: _____ / _____ / _____ Page _________ of ________ Source Designation: __________________________

	FOR AGENCY USE ONLY
SUPPLEMENT TO CAAPP APPLICATION	ID NUMBER:
	PERMIT #:
	DATE:

THIS FORM SHALL ACCOMPANY ANY SUPPLEMENT TO A CAAPP APPLICATION, THAT IS, ANY SUBMITTAL OF NEW OR CORRECTED INFORMATION FOR A PENDING CAAPP APPLICATION.

SOURCE INFORMATION

1) SOURCE NAME: **Advanced Disposal Services – Zion Landfill, Inc.**

2) DATE FORM PREPARED:	3) SOURCE ID NO. (IF KNOWN):
November 14, 2014	**097200AAV**

SUPPLEMENT INFORMATION

4) DOES THIS SUPPLEMENT PROVIDE ADDITIONAL INFORMATION? ■ Yes ☐ No

IF YES, COMPLETE THE FOLLOWING:

NUMBER OF NEW PAGES IN THIS SUPPLEMENT: ____**See Below**____________

	EMISSION UNIT, EQUIPMENT, OR SUBJECT THAT THIS SUPPLEMENT ADDRESSES	UNIT DESIGNATION	NEW PAGE #(S)	
	Form 505 – Supplement to CAAPP Application	**N/A**	**505-1 & 505-2**	
	Updated NSPS Landfill Gas Collection and Control System Design Plan	**N/A**	**I-1 to IV-18 & Appendices A through E**	

THIS AGENCY IS AUTHORIZED TO REQUIRE THIS INFORMATION UNDER ILLINOIS REVISED STATUTES, 1991, AS AMENDED 1992, CHAPTER 111 1/2, PAR. 1039.5. DISCLOSURE OF THIS INFORMATION IS REQUIRED UNDER THAT SECTION. FAILURE TO DO SO MAY PREVENT THIS FORM FROM BEING PROCESSED AND COULD RESULT IN THE APPLICATION BEING DENIED. THIS FORM HAS BEEN APPROVED BY THE FORMS MANAGEMENT CENTER.

APPLICATION PAGE ________

FOR APPLICANT'S USE
____

5) DOES THIS SUPPLEMENT CORRECT PREVIOUSLY SUBMITTED INFORMATION? IF YES, COMPLETE THE FOLLOWING:	☐ Yes ■ No

NUMBER OF REVISED PAGES IN THE SUPPLEMENT: ______

	EMISSION UNIT, EQUIPMENT, OR SUBJECT THAT THIS SUPPLEMENT ADDRESSES	UNIT DESIGNATION	OLD PAGE #(S)	NEW PAGE #(S)	

SIGNATURE BLOCK

6) I CERTIFY UNDER PENALTY OF LAW THAT, BASED ON INFORMATION AND BELIEF FORMED AFTER REASONABLE INQUIRY, THE STATEMENTS AND INFORMATION CONTAINED IN THIS APPLICATION, AS AMENDED BY THIS SUPPLEMENT, ARE TRUE, ACCURATE AND COMPLETE.

AUTHORIZED SIGNATURE:

BY:	James A. Lewis	General Manager
	AUTHORIZED SIGNATURE	TITLE OF SIGNATORY
	James A. Lewis	11 / 18 / 14
	TYPED OR PRINTED NAME OF SIGNATORY	DATE

Updated NSPS Landfill Gas Collection and Control System Design Plan ADS - Zion Landfill Expansion

Prepared for

ADS - Zion Landfill

Zion, Illinois

December, 2014

Prepared by

Environmental Information Logistics, LLC
130 E. Main Street
Caledonia, Michigan 49316

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TABLE 1 SUMMARY OF LANDFILL GAS COLLECTION AND CONTROL SYSTEM DESIGN PLAN

Regulatory Citation	*Report Reference*	*Appendix E Reference [1]*	*Regulatory Requirement*	*Implementation of Regulatory Requirement*
§60.759 (a)(1)	Section 1.3	Page E-3, Section 2	Landfill gas collection and control system design plan must be certified, sealed and signed by a professional engineer.	Landfill gas collection and control system design plan has been certified, sealed and signed by a professional engineer.
	Section 4-1	Page E-3, Section 3	Design Plan must address depth of refuse, refuse gas generation rates and flow characteristics, cover properties, gas system expandability, leachate and condensate management, accessibility, compatibility with filling operations, integration with closure end-use, air intrusion control, corrosion resistance, fill settlement, resistance to the refuse decomposition heat.	The updated ADS - Zion Landfill Site 2 East Horizontal Expansion design plan addresses all of the requirements listed under §60.759 (a)(1).
§60.759 (a)(2)	Section 4-2	Page E-3, Section 4	Landfill gas collection devices shall be installed at a sufficient density to control surface emissions and subsurface migration of landfill gas.	The landfill gas collection devices have been designed to control surface emissions and subsurface migration of landfill gas.
§60.759 (a)(3)(i)	Section 4-3.1	Page E-3, Section 5	Areas containing asbestos or other non-degradable materials may be excluded from coverage by the landfill gas collection and control system	There are no areas proposed for exclusion from control based on non-degradable waste types.
§60.759 (a)(3)(ii)	Section 4-3.1	Page E-3, Section 6	Areas considered to be non-productive (contributing less than 1 percent of the total non-methane organic compounds from the landfill) may be excluded from coverage of the landfill gas collection and control system.	There are no areas of the landfill deemed to be non-productive at this time. Therefore, no areas are currently proposed for exclusion from control.

Regulatory Citation	***Report Reference***	***Appendix E Reference*** [1]	***Regulatory Requirement***	***Implementation of Regulatory Requirement***
§60.759 (b)(1)	Section 4-4.1	Page E-5, Section 7	Landfill gas collection and control system components shall be constructed of PVC, HDPE or other non-porous corrosion resistant materials.	Landfill gas collection and control system components will be constructed of PVC, HDPE or other non-porous corrosion resistant materials.
	Section 4-4.1	Page E-5, Section 8	Landfill gas collection and control system components shall have suitable dimensions to convey the maximum landfill gas flow rate and withstand future settlement, overburden and traffic loads.	Landfill gas collection and control system components were designed to accommodate the maximum landfill gas flow rate and withstand future settlement, overburden and traffic loads.
	Section 4-4.1	Page E-5, Section 9	Expansion of the landfill gas collection and control system will occur as needed to meet landfill gas emissions and migration standards.	Expansion of the landfill gas collection and control system will occur as needed to meet landfill gas emissions and migration standards.
	Section 4-4.1	Page E-5, Section 10	Extraction well perforations will control head loss and air infiltration throughout the system,	The landfill gas collection elements are perforated to minimize head loss and prevent excessive air infiltration into the system.
§60.759 (b)(2)	Section 4-4.2	Page E-5, Section 11	Extraction wells must not endanger the landfill base liner and must address the occurrence of water in the landfill.	The landfill gas extraction wells are designed and installed to extend from the landfill surface to no closer than ten feet to the base liner. Liquids in the refuse are addressed by the leachate and condensate management systems.
	Section 4-4.2	Page E-5, Section 12	Suitable cross-section of the well holes and trenches is required for construction and completion of the collection elements.	The vertical boreholes and/or interim horizontal trenches will be constructed with sufficient cross section to allow for the proper construction of the collection elements.

Regulatory Citation	***Report Reference***	***Appendix E Reference*** [1]	***Regulatory Requirement***	***Implementation of Regulatory Requirement***
§60.759 (b)(2)	Section 4-4.2	Page E-5, Section 13	Landfill gas collection and control system components must be designed to control air intrusion, prevent landfill gas from escaping the collection system, and prohibit refuse from entering the collection system.	Control of air intrusion and the escape of landfill gas from the system will be accomplished through the monitoring of the landfill gas collection and control system, operating the system under vacuum and continued maintenance of the landfill cover. The refuse is prohibited from entering the collection devices by stone backfill or other approved materials placed in the hole or trench separating the refuse from the landfill gas collection elements.
	Section 4-4.2	Page E-5, Section 14	Stone backfill in the extraction wells and trenches shall not obstruct pipe perforations.	Backfill of sufficient size will be used to prohibit entry or blockage of the collector perforations.
§60.759 (b)(3)	Section 4-4.3	Page E-5, Section 15	Collection device connections may be above or below ground, must include a positive closing throttling valve, necessary seals, access couplings, and at least one monitoring point.	The collection devices are connected to the collection header pipe and include a positive closing throttling valve, necessary seals, access couplings, and a minimum of one monitoring point.
§60.759 (c)	Section 4-5	Page E-5, Section 16	The collection header pipes must be adequate to handle the maximum landfill gas flow rate.	The collection header pipes are sized to adequately handle the maximum landfill gas flow rate.
§60.752 (b)(2)(ii)(A)(*2*)	Section 4-6.4	Page E-2, Section 2	Landfill gas collection shall occur in active cells with waste in place for five years or more; in closed cells with waste at final grade for two years or more.	The landfill gas collection and control system components will be installed per NSPS schedule requirements.
§60.752 (b)(2)(ii)(A)(*3*)	Section 4-6.4	Page E-2, Section 3	Landfill gas extraction wells shall apply a negative gauge pressure to maintain a sufficient extraction rate of landfill gas without causing air infiltration.	A negative gauge pressure is applied to the landfill gas collection elements via centrifugal blowers. The landfill gas collection system wellheads will be monitored for static pressure and indications of air infiltration.
§60.752 (b)(2)(ii)(A)(*4*)	Section 4-6.4	Page E-2, Section 4	Subsurface migration of landfill gas will be controlled.	The landfill gas collection and control system shall control subsurface migration which will be verified by periodic monitoring for subsurface gas in surrounding installed gas probes as required by IEPA.

[1] Appendix E of the "Enabling Document for the New Source Performance Standards and Emissions Guidelines for Municipal Solid Waste Landfills", Emission Standards Division, US EPA.

TABLE 2 - LANDFILL GAS COLLECTION AND CONTROL SYSTEM (GCCS) DESIGN REVIEW CHECKLIST

Landfill Site Name: ADS-Zion Landfill
Location of Landfill: Zion, Illinois
Landfill Owner: ADS-Zion Landfill

Date of Submittal: December, 2014

Goals for the GCCS: control migration control emissions safety
(~~circle all~~ that apply, ~~add more as~~ appropriate)

Is the GCCS proposed to be active or passive? (circle one)

The proposed GCCS is active in nature and should serve to mitigate the potential for both subsurface and airborne migration, as well as the potential for accumulation in occupied structures.

1. Was the design certified by a PE? **60.752(b)(2)(i)** Yes No
(circle one)

   Laura L. Niemann, P.E. is a Registered Professional Engineer in Illinois and has certified this Design Plan as the design engineer. Please reference Section 1 of the Design Plan.

2. Was the design submitted within 12 months of the ~~first~~ report of the site exceeding 50 Mg/yr. of NMOC's? **60.752(b)(2)(i)** Yes No
(circle one)

   If no, describe circumstances: The original design plan for the facility was submitted as required. This is an update to the plan to incorporate a horizontal expansion.

3. Is the GCCS planned to be operational within 30 months of ~~the~~ first report of the site exceeding 50 MG/yr. of NMOC's? **60.752(b)(2)(ii)** Yes No
(circle one)

If no, describe circumstances: *The GCCS began operation in 1997. The site exceeded 50 Mg/yr of NMOC's in June 1996.*

4. Does the GCCS comply with the 2 year/5 year rule? **60.752(b)(2)(ii)(A)(2)**
   Yes No
   (circle one)

   If no, describe circumstances:

5. What is the design life of the GCCS? **60.752(b)(2)(v)** > 15 years
   (If less than 15 years describe why)

6. Is the GCCS design for the ~~maxim~~um expected flow rates during its design life?
   60.752(b)(2)(ii)(A)(1) Yes No
   (circle one)

   If no, describe circumstances:

7. Describe the measures taken to control lateral LFG migration in the design. If no measures were taken, describe why? **60.752(b)(2)(ii)(A)(4)** *The design of the GCCS uses active extraction to mitigate the potential for lateral LFG migration. This process is enhanced by the presence of a composite liner (5 foot minimum clay and flexible membrane liner (FML) base liner system in most areas of the site and a minimum 5' foot thickness clay liner in non-composite lined areas. Please reference Section 4.1 of the Design Plan.*

8. If a passive system is planned, are the necessary liners in place?
   60.752(b)(2)(ii)(B)(2) Yes No
   (circle one)
   If no, describe circumstances: *Not Applicable – an active system is proposed.*

9. Is adequate density of collectors planned? Yes No
   (circle one)

   If no, describe circumstances:

10. Is the LFG Conveyance System sized properly?
    Yes No
    (circle one)

The LFG conveyance system is adequately sized to handle the current projected LFG generation rate as determined using the United States Environmental Protection Agency (USEPA) LandGEM V3.02 and is expandable. The LFG conveyance system will be expanded to handle future LFG generation rates in accordance with the New Source Performance Standards (NSPS) to mitigate surface and lateral LFG migration.

11. Is the LFG planned to be routed to a control device? **60.752(b)(2)(iii)**

    Yes No
    (circle one)

    Please reference Section 4.6.5 of the Design Plan.

12. Describe the control device utility flare enclosed flare other
    (circle one)

    The existing control devices consist of a utility flare, an enclosed flare, and a five engine landfill gas to energy plant which treats the gas prior to combustion. The devices are operated in accordance with §60.752(b)(2)(iii)(A),(B) and (C). Please reference Section 4.6.5 of the Design Plan.

13. If the control device is a flare, does it include continuous temperature monitoring and a flow measurement device? **60.756(b) and (c)** Yes No
    (circle one)

    If no, describe circumstances:____________________

14. Is the flare sized properly?

    Yes No
    (circle one)

    The existing flares are sized for the maximum design flow rate in accordance with §60.752(b)(2)(ii)(A). Please reference Section 4.6.5 of the Design Plan.

15. If a control device other than a flare is planned, describe the estimated hours and duration it will be down for maintenance per year:

    A landfill gas to energy plant with five engines exists at the site. The site also maintains two flares for back-up/supplemental gas control when the gas plant engines are down for maintenance or repair.

16. Operational Issues **60.753(b), (c), (d), (e), (f)**
    Will the GCCS be operated with a vacuum at every well? Yes No

The GCCS operates with a vacuum at each extraction point, with the exception of mitigating circumstances allowed under §60.753(b)(1).

17. Will the GCCS be operated at the appropriate gas temps? Yes No

The GCCS is intended to operate at LFG temperatures below 55ºC (131ºF) unless the facility has applied for/received approvals for Higher Operating Values for temperature from USEPA.

18. Will the GCCS be operated with minimal amounts of air? Yes No

The GCCS is designed to prevent excessive air infiltration. Please reference Section 4.1.10 of the Design Plan.

19. Will monitoring be done monthly to confirm these operational issues?
Yes No

Monitoring is conducted in accordance with NSPS requirements. Please reference Section 4.2 of the Design Plan.

20. Will surface emissions monitoring be completed? Yes No

Monitoring is conducted in accordance with NSPS requirements. Please reference Section 4.2 of the Design Plan.

21. Will the blower automatically be shutdown if the control device is inoperable?
Yes No

The blower system automatically shuts down if the associated control devices become inoperable. Please reference Section 4.6.5 of the Design Plan.

22. Does the GCCS include fittings to allow connection of additional collectors if necessary in the future? **60.756(2)** Yes No
(circle one)

If no, describe circumstances: ______________________________

Does the wellhead for all collectors include at least one sample port and one thermometer port? 60.756(2) Yes No
(circle one)

If no, describe circumstances: ______________________________

1 INTRODUCTION AND CERTIFICATION

1.1 Purpose

The purpose of this document is to provide an updated design plan in accordance with the Federal New Source Performance Standards (NSPS) for Municipal Solid Waste Landfills for the ADS - Zion Landfill's Site 2 East Horizontal Expansion in Zion, Lake County, Illinois. This document serves as the updated Landfill Gas Collection and Control System Design Plan (NSPS Design Plan) for the site's gas collection and control system (GCCS) and was prepared pursuant to 40 Code of Federal Regulations (CFR) Part 60, Subpart WWW, NSPS for Municipal Solid Waste Landfills. The Illinois Environmental Protection Agency (IEPA) approved the above mentioned horizontal expansion via issuance of Air Construction Permit No. 12070062, dated October 30, 2014.

This design plan incorporates the horizontal expansion. The design plan currently in effect at the site was submitted to IEPA on September 30, 2002 with updates provided on February 5, 2004 and March 24, 2005. It was approved by IEPA as part of a Significant Modification to CAAPP Permit 97030064 on November 6, 2006 and replaced the original plan submitted in June of 1997. An updated design plan to incorporate the previously approved vertical expansion (Construction Permit No. 11030009) was last submitted to IEPA on August 15, 2012 as part of a CAAPP Renewal Additional Information submittal.

1.2 Compliance Summary Table

A summary of the pertinent NSPS regulations and implementation of these regulations at the ADS - Zion Landfill is presented in Table 1 of this Design Plan. Additionally, location references of the regulations in this Design Plan and in Appendix E of the NSPS enabling document are presented. Table 2 provides a Design Plan checklist.

1.3 Certification

This updated NSPS Design Plan for the GCCS at the ADS - Zion Landfill, incorporating the permitted Site 2 East Horizontal Expansion has been prepared by Environmental Information Logistics, LLC (EIL), as authorized by ADS - Zion Landfill, Inc. which owns and operates the GCCS at the ADS - Zion Landfill.

I certify that the Updated Landfill Gas Collection and Control System Design Plan for the ADS - Zion Landfill was prepared in general accordance with the requirements of 40 CFR 60 Subpart WWW.

LAURA L. NIEMANN 062-049010 LICENSED PROFESSIONAL ENGINEER OF ILLINOIS

Laura L. Niemann, P.E.
IL PE License No. 062-049010

12/3/2014

Section 2

2 EXISTING SITE CONDITIONS

2.1 Landfill Description

The ADS - Zion Landfill is subject to the New Source Performance Standards (NSPS) for municipal solid waste landfills, promulgated March 12, 1996. The facility showed calculated facility emissions in excess of 50 Mg/year NMOC in June, 1996 utilizing the Tier 1 NSPS defaults. As required by the NSPS regulations, the facility prepared and submitted a Landfill Gas Collection and Control System Design Plan (NSPS Design Plan) in June, 1997 to the Illinois EPA.

In June 2002, the facility completed a redesign of the gas collection system. A revised NSPS Design Plan was submitted to IEPA on September 30, 2002. Updates to the revised plan were provided to IEPA on February 5, 2004 and March 24, 2005. The plan was approved as part of the Significant Modification to CAAPP Permit 97030064, issued November 6, 2006.

On August 15, 2012, the facility submitted an updated NSPS Design Plan to incorporate the Site 2 East Vertical Expansion that was approved via issuance of Construction Permit No. 11030009. This current update to the design plan is to incorporate the recently approved Site 2 East Horizontal Expansion via issuance of Construction Permit No. 12070062. The Site 2 East Horizontal Expansion expands the landfill horizontally to the east of the existing disposal units and vertically over the portions of existing Site 2 expansion area.

As a result of this expansion, the previously-designed and approved gas collection system will require modification to accommodate the additional waste volumes.

The existing areas of final cover at the ADS- Zion Landfill have been installed in phases over the life of the facility, and consist of two basic cover systems. These include:

- Three feet of compacted cohesive soils, geocomposite drainage layer, 2.5 feet of protective soils, and six inches of vegetative soil (Portion of Phase 1a); and
- Two feet of compacted cohesive soils, 40 mil geomembrane, geocomposite drainage layer, 2.5 feet of protective soils, six inches of vegetative soil (remainder of currently closed areas at site)

The other currently uncapped areas at the site, including the footprint of the recently approved Site 2 East Horizontal Expansion (26.5 acres to the east of the existing waste footprint) will consist of the following final cover system:

- 24 inches of compacted low permeability soil;
- 40 mil geomembrane liner;
- Geocomposite drainage net;
- A minimum of 30 inches of protective soil; and
- 6 inches of soil capable of supporting vegetation

2.2 Landfill Gas Collection and Control System

The closed portions of the landfill (Phases 1a and 1b, and Old Site 2) have a complete gas system in place. As-built locations are shown in Appendix C.

The active portion of the landfill (Site 2 expansion and Site 2 East vertical expansion) has a gas system in place over the majority of the constructed landfill area. The NSPS requires installation of controls in areas of waste that are two years of age and at final grade, or in areas of waste that are five years of age and not at final grade. ADS – Zion Landfill has and will continue to exceed this requirement by collecting gas from leachate sumps/cleanout risers in the newer areas of waste and through installation of temporary vertical wells prior to the aforementioned timeframes.

The facility will continue to operate the existing gas collection wells in the footprint of the Site 2 expansion and Site 2 East vertical expansion as long as possible by extending the well casing upwards as new lifts of waste are filled around each well. Care will be taken by operations personnel to protect the wells during filling operations. Once the wells become non-functional, the facility will replace them via drilling replacement wells at the new waste grades.

The evolution of the collection and control system as the landfill is filled will ultimately produce the design specified in this plan. Until the landfill has attained the final grades, the collection and control of landfill gas pursuant to the NSPS may be accomplished using methods not specifically included as part of the final design (i.e. horizontal trenches, connections to leachate cleanout risers and sumps, connections to leachate recirculation lines, etc.). However, once the facility has reached the final permitted grades, the collection and control system will meet the criteria specified within this design plan.

Permanent lateral and header pipes are installed generally below ground surface and are typically constructed of high density polyethylene (HDPE) pipe. Temporary piping may be installed either above or below ground surface. LFG is conveyed through this pipe network to the control devices. Additional information on the control system can be found in Section 4.6.5 of this document.

The header line is designed with engineered low spots from which condensate can be removed continuously. Condensate from the gas collection system is commingled with leachate, and the liquids are collected in on-site storage tanks. Some condensate/leachate is recirculated, and the remainder is hauled by truck to a POTW, where it is discharged and treated.

A portion of the collected gas is sent to a third party landfill gas to energy facility where gas is combusted in five reciprocating internal combustion engines. Prior to combustion, the landfill gas is treated via filtration, dewatering and compression. Only the gas sent to the engines is treated. The gas to energy plant received a Treatment Applicability determination from USEPA on August 11, 2004. The remainder of the untreated collected gas is sent to either an open flare or an enclosed flare for combustion. The combination of these control devices is sized to control the anticipated gas volumes from the existing permitted landfill including the most recent expansion. Additional information and drawings of the existing and proposed GCCS are included in Appendix C.

Section 3

3 FUTURE SITE DEVELOPMENT

3.1 Landfill Development Plan

ADS - Zion Landfill will continue waste filling operations including at the active Site 2 East Horizontal expansion area in accordance with the solid waste permit. Installation of GCCS components is anticipated to be coordinated with fill development and as otherwise required by NSPS regulations regarding installation of GCCS components stipulated in §60.752(b)(2)(ii)(A)(2). As stated in Section 2.2, the development of the vertical and horizontal expansion over the existing landfill gas collection system will occur in stages. Existing gas collection wells will be raised to accommodate the higher landfill elevations. If a well becomes non-functional, it will be re-drilled/replaced in accordance with the requirements of the NSPS, and any alternative timelines approved by the regulatory authority.

Due to operational changes, the GCCS design presented in Appendix C may be revised to maintain compliance with the provisions of the NSPS and to accommodate existing field conditions at the time of construction.

3.2 Landfill Gas Control System Expansion Capabilities

The GCCS will be designed to be expanded as fill operations proceed. Vertical wells will typically be installed in areas that are at or close to final grade. Vertical wells and/or horizontal collection trenches may be installed as an interim control measure in disposal areas that have been in place for more than five years, but that are not yet at final refuse grades. The site may also choose to collect gas from leachate sumps and cleanout risers, or leachate recirculation lines.

Vertical extraction wells installed prior to reaching final grade may either be extended to the final grade level or abandoned and replaced. The determination will be made based upon the physical condition of the wells, their ability to provide effective LFG extraction, and field conditions at the time of final cover installation.

LFG headers will be sized to accommodate the maximum expected flow, and be fitted with flanged tees and blind flanges or capped ends for expansion as new collectors are installed, in accordance with NSPS requirements. Additionally, the use of HDPE header piping provides for efficient and flexible connections for future expansion of the header piping system.

The site's control devices are currently sized to handle the permitted facility's gas flow, including the projected gas flow from the recently approved expansion.

3.3 Construction Quality Assurance

Construction of the GCCS will be monitored and documented. This includes air testing of piping, documentation of vertical well drilling depth, and preparation of as-built drawings as required by 40 CFR 60.758(d).

4 COMPLIANCE REVIEW AND EVALUATION

4.1 Compliance with §60.759(a)(1)

> **§60.759(a)(1)** The collection devices within the interior and along the perimeter areas shall be certified to achieve comprehensive control of surface gas emissions by a professional engineer. The following issues shall be addressed in the design: depths of refuse, refuse gas generation rates and flow characteristics, cover properties, gas system expandability, leachate and condensate management, accessibility, compatibility with filling operations, integration with closure end use, air intrusion control, corrosion resistance, fill settlement, and resistance to the refuse decomposition heat.

The GCCS has been designed to be consistent with NSPS requirements to achieve comprehensive control of both surface emissions of LFG and lateral migration.

Issues related to compliance with §60.759(a)(1) are discussed in the following sections.

Applicable information used in the design of the GCCS is included in Appendix A (A-1: Gas Generation Rate Modeling, A-2: Radius of Influence and Well Spacing Calculations, and A-3: Positive Pressure Allowances, Appendix B (Head Loss Analysis), Appendix C (GCCS Design Plans), and Appendix D (Surface Emissions Monitoring Plan).

4.1.1 Control of Surface Emissions

The GCCS was designed to minimize both surface emissions and subsurface lateral migration of LFG from the ADS - Zion Landfill. System performance depends upon the proper installation of a GCCS system, its management, and construction/maintenance of a final cover system. If there is an exceedance in emissions, it will be addressed in accordance with appropriate regulatory requirements, which can include evaluating both the GCCS and the landfill cover systems. Appropriate actions will be taken to correct the exceedance as stipulated by the NSPS.

4.1.2 Depths of Refuse

Cell depths vary from 40 to 60 feet below grade while landfill heights average 195 feet above grade. The maximum refuse depth will be approximately 230 feet.

4.1.3 Landfill Gas Generation Rates and Flow Characteristics

A detailed discussion of landfill gas generation rate modeling is provided in Appendix A-1. In accordance with §60.752(b)(2)(ii)(A), the maximum expected LFG flow rate for the site was used for sizing the GCCS.

The LFG generation rate calculations for the expansion of the active Site 2 area were performed using the EPA's Landfill Gas Emission Model (LandGEM). The value for the Methane Generation Rate Potential (k) was obtained from AP-42 (Fifth Edition, Volume 1, Chapter 2.4). It was assumed that k = 0.04 year^{-1}. The value used for Methane Generation Potential (Lo) was assumed to be = 140 m^3 methane/megagram solid waste. This provides an estimate of theoretical yield that is consistent with the collected volumes observed from the waste in place to date. Data for waste receipts and gas generation factors utilized is provided in Appendix A-1.

The calculations are separated into three different parts based on variable waste composition, leachate management practices and the current (i.e., closed or active) for the separate areas. The three parts are: Closed Phase 1a co-disposal area, closed Phase 1b and Site 2 MSW areas, and active MSW area. In the year 2024, the total combined "maximum" gas flow rate for the entire facility, after the waste is placed to final permitted grades, is estimated to be 8,319 ft^3/min. The proposed GCCS components to be installed in the ADS Zion Landfill were therefore sized to accommodate a LFG flow rate of 8,319 ft^3/min as required by the NSPS.

4.1.4 Landfill Cover Properties

As described earlier in Section 2.1, the landfill cover systems installed at the ADS - Zion Landfill consist of two different cover system designs, including a soil-only cover over a portion of the closed Phase 1a portion of the site, and a soil/geosynthetic cover over the remainder of the existing permitted site including the vertical and horizontal expansions.

The primary purpose of the final cover system is to reduce infiltration of precipitation that would generate additional leachate. However, the final cover system design also provides a significant barrier to LFG emissions and air infiltration when combined with the active LFG extraction system. An active GCCS will help to relieve pressures from LFG beneath the landfill covers.

4.1.5 Landfill Gas Control System Expandability

Expandability of the GCCS is achieved by installing blind flanges or caps along the transmission piping, which allows the LFG transmission piping to be easily expanded in the future. In the event that actual LFG flow rates do exceed the capacity of the system, additional GCCS components will be designed and installed in accordance with NSPS requirements. The HDPE LFG piping is easily expandable by field welding additional piping to the collection system.

4.1.6 Leachate and Condensate Management

The header line is designed with engineered low spots from which condensate can be removed continuously. LFG piping grades within refuse is maximized where practical to reduce the impact of differential settlement and promote positive condensate drainage. Proposed transmission header and lateral piping will be sloped at a minimum of 5 percent when placed on waste and 0.3 percent when placed on soils to promote condensate to flow by gravity to engineered low points in the GCCS piping, for collection of the condensate. Condensate collection pump stations or drains to LCS components are/will be located at these low points, to collect the condensate and remove it from the transmission piping.

Condensate from the gas collection system is commingled with leachate, and sent to on-site leachate tanks. The leachate is periodically removed and sent off-site for disposal/treatment at a POTW. The site is permitted to conduct leachate recirculation in the active area and has installed trenches within the waste to accomplish this.

4.1.7 Accessibility

Accessibility to the GCCS components is achieved by installing commonly accessed components (such as wellheads, monitoring ports, etc.) on relatively flat surfaces of the landfill or near the landfill's road network. The GCCS will be predominately installed below grade; however, valves and monitoring ports will be installed above grade, or within vaults, to increase their accessibility. The final LFG piping system is generally designed with the piping predominantly located inside the waste disposal area on soils at crest of the liner slope or above the final membrane liner where on waste.

4.1.8 Compatibility with Refuse Filling Operations

Gas extraction devices will be installed within 60 days of the date in which the initial solid waste has been in place for a period of 5 years or more if active, or 2 years or more if closed or at final grade. Methods for gas collection may include vertical gas extraction wells, extraction from the leachate collection system, extraction from the leachate recirculation system, horizontal trenches, etc. The methods selected for each area will take into account the stage of filling operations occurring in the area, in order to minimize damage to the collection system from landfill traffic.

With respect to the vertical expansion over areas of the site that already have a gas collection system installed, as stated in Section 2.2, the facility will continue to operate the existing gas collection wells in the footprint of the vertical expansion as long as possible by extending the well casing upwards as new lifts of waste are filled around each well. Care will be taken by operations personnel to protect the wells during filling operations. If the wells become non-functional due to waste settlement or if the solid pipe extensions become so great that gas cannot be collected in the upper levels of waste, the facility will selectively replace wells by redrilling them at the new waste grades or supplementing them with additional shallow wells to collect gas from upper levels of waste.

As refuse filling operations proceed and portions of the site reach final or near-final grades, additional GCCS components will be installed. Using this method allows GCCS components to be installed in accordance with §60.752(b)(2)(ii)(A)(2)(i) and (ii) while minimizing interference of the GCCS with ongoing filling operations.

4.1.9 Integration with Closure End Use

Future land use for the ADS - Zion Landfill will be open space. The end use plan will not disturb the integrity of the gas control system, final cover system, or any other components of the containment or monitoring system.

4.1.10 Air Intrusion Control

Air intrusion and LFG emissions will be controlled through periodic monitoring and adjustment of the GCCS in coordination with appropriate maintenance of the landfill cover system. Further, air intrusion control will be accomplished through monitoring of the operational monitoring standards for the LFG collection elements in accordance with NSPS requirements. If the GCCS does not meet the operational monitoring standards, it will be adjusted or modified in accordance with NSPS requirements.

4.1.11 Corrosion Resistance

Corrosion resistance of the GCCS is achieved through the use of corrosion resistant materials or materials that have a corrosion resistant coating, in accordance with 40 CFR§60.759(b)(1). The primary components used in the construction of the GCCS are HDPE and PVC piping or other non-porous corrosion resistant material.

4.1.12 Fill Settlement

Settlement will occur due to decomposition of the refuse. To accommodate refuse settlement, the GCCS components were designed and installed with several features to account for this settlement including:

- LFG extraction wellheads connected to the LFG transmission piping via a flexible pipe or hose connection. This allows the LFG piping to accommodate changes in the orientation of the LFG transmission piping or LFG extraction well.

- LFG transmission piping was sloped at sufficient grades so that reasonable amounts of differential and total settlement may occur without causing pipe breakage, or disrupting the overall flow gradient of the LFG transmission piping.

- HDPE piping will be used for the construction of the header piping and transmission system. HDPE piping is flexible and absorbs differential settlement without breaking or cracking.

4.1.13 Resistance to Decomposition Heat

Resistance of the GCCS to the heat generated as a result of refuse decomposition is achieved through the use of materials tested and proven to withstand temperatures well above those typically found in landfills. Landfill gas temperature will be monitored periodically in accordance with operational monitoring standards for the LFG collection elements as required by NSPS. The GCCS will be adjusted or modified to mitigate potential effects of elevated temperatures when warranted.

4.2 Compliance with §60.759(a)(2)

> **§60.759(a)(2)** The sufficient density of gas collection devices determined in paragraph (a)(1) of this section shall address landfill gas migration issues and augmentation of the collection system through the use of active or passive systems at the landfill perimeter or exterior.

Pursuant to §60.751, "sufficient density" means "any number, spacing, and combination of collection system components. . . necessary to maintain emission and migration control as determined by measures of performance set forth in this part." Well spacing at the ADS - Zion Landfill Horizontal Expansion was established using the Darcy Radius of Influence method, as described in Appendix A-2. This is consistent with spacing methodology used previously at this landfill as well as at other landfills and should effectively control subsurface migration and surface emissions of LFG in accordance with NSPS requirements.

The ADS - Zion Landfill conducts quarterly surface emissions monitoring in accordance with its CAAPP permit and the NSPS. If the GCCS at the facility does not meet the measures of performance for surface scans set forth in the NSPS, the active GCCS is adjusted or modified in accordance with the NSPS requirements. These corrective actions include the installation of additional collection elements, cap repairs or other actions defined by field conditions at the time of monitoring. These quarterly surface scans help the site demonstrate that the in-place collection system contains collection system components that are placed at sufficient density to control surface emissions of methane.

4.3 Compliance with §60.759(a)(3)

> **§60.759(a)(3)** The placement of gas collection devices determined in paragraph (a)(1) of this section shall control all gas producing areas, except as provided by paragraphs (a)(3)(i) and (a)(3)(ii) of this section.

The GCCS system compliance with §60.759(a)(3) is discussed in the following sections.

4.3.1 Asbestos and Non-degradable Materials

> **§60.759(a)(3)(i)** Any segregated area of asbestos or non-degradable material may be excluded from collection if documented as provided under §60.758(d). The documentation shall provide the nature, date of deposition, location and amount of asbestos or non-degradable material deposited in the area, and shall be provided to the Administrator upon request.

The ADS - Zion Landfill is not proposing to exclude any areas from gas control in accordance with 60.759(a)(3)(i) based on non-degradable waste types. There are no monofill areas at the site; non-degradable waste is commingled with MSW waste during disposal.

4.3.2 Nonproductive Areas

> **§60.759(a)(3)(ii)** Any nonproductive area of the landfill may be excluded from control, provided that the total of all excluded areas can be shown to contribute less than 1 percent of the total amount of NMOC emissions from the landfill. The amount, location, and age of the material shall be documented and provided to the Administrator upon request. A separate NMOC emissions estimate shall be made for each section proposed for exclusion, and the sum of all such sections shall be compared to the NMOC emissions estimate for the entire landfill.

No areas of the site have been determined to be non-productive at this time (i.e., they contribute <1 percent of the total amount of NMOC emissions from the landfill) per 60.759(a)(3)(ii). Therefore, no areas are proposed for exclusion from NSPS collection and control requirements.

4.4 Compliance with §60.759(b)(1), (2), and (3)

> **§60.759(b)** Each owner or operator seeking to comply with §60.752(b)(2)(i)(A) shall construct the gas collection devices using the following equipment or procedures:

4.4.1 Landfill Gas Extraction Component Construction

> **§60.759(b)(1)** The landfill gas extraction components shall be constructed of polyvinyl chloride (PVC), high density polyethylene (HDPE) pipe, fiberglass, stainless steel, or other non-porous corrosion resistant material of suitable dimensions to: convey projected amounts of gases; withstand installation, static, and settlement forces; and withstand planned overburden or traffic loads. The collection system shall extend as necessary to comply with emission and migration standards. Collection devices such as wells and horizontal collectors shall be perforated to allow gas entry without head loss sufficient to impair performance across the intended extent of control. Perforations shall be situated with regard to the need to prevent excessive air infiltration.

The GCCS's compliance with §60.759(b)(1) is discussed in the following sections.

4.4.1.1 Materials

The GCCS components will be constructed of HDPE, PVC, corrosion-resistant steel, fiberglass, Neoprene (gaskets and seals) and/or other non-porous corrosion resistant materials.

4.4.1.2 Component Sizing

A KYGAS analysis was performed for the entire facility in order to verify minimum pipe sizing for the maximum projected landfill gas flows. This analysis is provided in Appendix B.

4.4.1.3 Component Loading

The GCCS components have been designed to withstand the estimated installation, static, overburden, settlement and traffic loads. Installation loads are insignificant for GCCS components based on the installation methods used. Static loads from the vacuums applied to the GCCS components and applied loads on the GCCS have been evaluated for other systems. Vacuum loads required for the GCCS operation are less than the allowable vacuum loads for the GCCS components.

The design methods for GCCS components within the landfill are consistent with those at this and other landfills that have been in place for extended periods of time (in excess of 15 years) and have been verified to withstand applied static and settlement forces. Transmission piping that extends beneath roadways will be protected from traffic either by utilizing a protective outer casing, as shown in the GCCS plan details in Appendix C, or by additional mounding of soil or other protective material above the pipe. The use of a granular bedding material around the header pipe offers a higher factor of safety against pipe failure.

4.4.1.4 System Expansion

The GCCS shall be expanded periodically to comply with NSPS installation requirements. ADS - Zion Landfill currently conducts monitoring and documents compliance of the GCCS at the facility in accordance with NSPS requirements. If the GCCS at the ADS - Zion Landfill does not meet the operational standards set forth in the NSPS, the GCCS will be adjusted or modified in accordance with NSPS requirements.

4.4.1.5 Component Perforation

The vertical wells may use the perforation pattern shown on the design plans (Appendix C) in order to allow LFG entry without incurring head losses sufficient to impair performance across the intended extent of control. The perforation patterns used for the ADS - Zion Landfill GCCS design have been successfully used in previous LFG system designs. Other perforation techniques may be utilized if they are determined to provide adequate LFG entry with minimal head loss.

4.4.1.6 Air Infiltration

The LFG collection elements have been designed to prevent air infiltration through the use of solid pipe and solid backfill near the ground surface for vertical LFG extraction wells. Hydrated bentonite plugs and geomembrane seals (for wells placed in areas of final cover) will be provided around vertical well casings where they penetrate the landfill final cover or interim cover systems. Further, air intrusion control will be measured through monitoring of the operational monitoring standards for the LFG collection elements in accordance with NSPS requirements. If the GCCS does not meet the operational performance standards, it will be adjusted or modified in accordance with NSPS requirements.

4.4.2 Landfill Gas Extraction Component Installation

> **§60.759(b)(2)** Vertical wells shall be placed so as not to endanger underlying liners and shall address the occurrence of water within the landfill. Holes and trenches constructed for piped wells and horizontal collectors shall be of sufficient cross-section so as to allow for their proper construction and completion including, for example, centering of pipes and placement of gravel backfill. Collection devices shall be designed so as not to allow indirect short circuiting of air into the cover or refuse into the collection system or gas into the air. Any gravel used around pipe perforations should be of a dimension so as not to penetrate or block perforations.

The GCCS system compliance with §60.759(b)(2) is discussed in the following sections.

4.4.2.1 Component Placement

Depths of refuse were calculated, at the time of the design of the GCCS, based upon existing base and future final grades for ADS – Zion Landfill Site 2 East Horizontal Expansion. Vertical LFG extraction wells were designed to extend from the landfill surface to no deeper than 10 feet above the landfill base, in order to prevent penetration of the base liner.

4.4.2.2 Leachate

The ADS - Zion Landfill is designed with leachate collection/removal systems. It is not expected that free liquids will be encountered during the drilling of wells for the vertical LFG extraction wells. If free liquids are encountered, the drilling contractor will attempt to drill through the perched zone of liquids in order to allow drainage into the underlying waste mass and the LCS. If the zone of perched liquids cannot be penetrated, the well installation may be terminated and well installation will be attempted at a nearby location.

If perched liquids are observed within the extraction wells after installation and the liquid level impedes LFG extraction, the leachate level will be reduced. This is normally accomplished by periodic pumping of the liquids via electric or pneumatic pumping systems.

4.4.2.3 Wells and Trenches

Vertical wells and interim horizontal trenches are of sufficient cross-section to allow for their proper construction and completion, including centering of the pipes and placement of granular backfill.

Record documentation of the GCCS component system installations will be maintained at the facility, as required by the NSPS.

4.4.2.4 Component Short Circuiting

LFG collection elements are designed to prevent air infiltration through the cover and direct venting of LFG to the atmosphere. Air intrusion control is/will be verified through monthly wellfield monitoring, quarterly monitoring of surface emissions and maintenance of the landfill cover in accordance with NSPS requirements. Separation of the collection elements from the surrounding refuse is managed by placing a granular backfill in the borehole space around extraction wells casings and the interim horizontal trench pipes, which provides a filter pack between the refuse and the LFG collection elements. Direct venting of the LFG to the atmosphere is avoided by operating the

GCCS under a vacuum and is verified by the quarterly monitoring of surface emissions (see Section 4.2).

4.4.2.5 Granular Backfill

Granular backfill of sufficient size and gradation is specified and utilized to prevent penetration or blockages of the LFG collector pipe perforations. As shown in Appendix C, the granular backfill material specified will be a nominal 1 to 3-inch in size.

4.4.3 Landfill Gas Extraction Component Connections to LFG Transmission Piping

> **§60.759(b)(3)** Collection devices may be connected to the collection header pipes below or above the landfill surface. The connector assembly shall include a positive closing throttle valve, any necessary seals and couplings, access couplings and at least one sampling port. The collection devices shall be constructed of PVC, HDPE, fiberglass, stainless steel, or other non-porous material of suitable thickness.

The extraction devices are connected to the collection header pipes using lateral piping. The lateral piping may be connected to the header piping either above or below the landfill surface, as required by field conditions at the time of installation. The connector assemblies will be located above grade. These assemblies include a valve, seals and couplings, and sampling ports. The extraction devices will be constructed of PVC, HDPE, fiberglass, corrosion-resistant steel, and other non-porous materials of suitable thickness. The GCCS components have been designed to withstand anticipated installation, static, settlement, overburden, and traffic loads.

4.5 Compliance with §60.759(c)(1) or (2)

> **§60.759(c)** Each owner or operator seeking to comply with §60.752(b)(2)(i)(A) shall convey the landfill gas to a control system in compliance with §60.752(b)(2)(iii) through the collection header pipe(s). The gas mover equipment shall be sized to handle the maximum gas generation flow rate expected over the intended use period of the gas moving equipment using the following procedures:

The GCCS's compliance with §60.759(c) is discussed in the following sections.

4.5.1 Existing Landfill Gas Flow Rate Data

> **§60.759(c)(1)** For existing collection systems, the flow data shall be used to project the maximum flow rate. If no flow data exists, the procedures in paragraph (c)(2) of this section shall be used.

A gas extraction system has been installed over the majority of the in-place waste at the ADS - Zion Landfill. Operating data from this system was utilized to establish suitable gas generation rates and theoretical yield values for the future system at the ADS - Zion Site 2 East Horizontal Expansion.

Per the most recent data provided by the site, the average collected gas flow rate in the year 2014 is approximately 3,800 cfm.

4.5.2 Future Landfill Gas Flow Rate Estimates

> **§60.759(c)(2)** For new collection systems, the maximum flow rate shall be in accordance with §60.755(a)(1).

Future gas flow rate estimates for the entire site at closure (including the horizontal expansion) are provided in Appendix A-1. A gas generation rate of 8,319 cfm was modeled.

4.6 Alternatives and Compliance with §60.752(b)(2)

> **§60.752(b)(2)** If the calculated NMOC emission rate is equal to or greater than 50 megagrams per year, the owner or operator shall:

Calculated NMOC emissions using Tier 1 defaults showed NMOC emissions of greater than 50 Mg/year when the NSPS was first promulgated in 1996. Therefore, the facility is subject to the New Source Performance Standards (NSPS) for municipal solid waste landfills. A Landfill Gas Collection and Control System Design plan is required for facilities with NMOC emissions of greater than 50 Mg/year.

4.6.1 Submit a Design Plan

> **§60.752(b)(2)(i)** Submit a collection and control system design plan prepared by a professional engineer to the Administrator within 1 year:

This document serves as the updated Landfill Gas Collection and Control System Design Plan (NSPS Design Plan) for the site's gas collection and control system (GCCS) and was prepared pursuant to 40 Code of Federal Regulations (CFR) Part 60, Subpart WWW, NSPS for Municipal Solid Waste Landfills. The design plan currently in effect at the site was submitted to IEPA on September 30, 2002 with updates on February 5, 2004 and March 24, 2005. It was approved by IEPA as part of a Significant Modification to CAAPP permit 97030064 on November 6, 2006 and replaced the original design plan submitted in June of 1997. An updated design plan to incorporate the previously approved vertical expansion (Construction Permit No. 11030009) was submitted to IEPA on August 15, 2012 as part of a CAAPP Renewal Additional Information submittal.

The submittal of this updated plan fulfills the requirement for the facility to prepare a collection and control system design plan in accordance with 40 CFR 60.752(b)(2). The design plan outlines the methodology employed to design a landfill gas management system that will collect and dispose of the landfill gas generated in the entire permitted landfill and the expansion at final grades.

4.6.2 Alternatives to the NSPS

> **§60.752(b)(2)(i)(B)** The collection and control system design plan shall include any alternatives to the operational standards, test methods, procedures, compliance measures, monitoring, record keeping or reporting provisions of §60.753 through §60.758 proposed by the owner or operator.

The following alternatives to the operational standards, test methods, procedures, compliance measures, monitoring, record keeping or reporting provisions of §60.753 through §60.758 of the NSPS have been approved by USEPA for the ADS - Zion Landfill:

4.6.2.1 Operational Standard LFG Collectors

> **§60.753(b)(3)** Operate the collection system with negative pressure at each wellhead except under the following conditions:
>
> (1) a fire or increased well temperature. The owner or operator shall record instances when positive pressure occurs in efforts to avoid a fire. These records shall be submitted with the annual reports as provided in §60.757(f)(1);
>
> (2) use of a geomembrane or synthetic cover. The owner or operator shall develop acceptable pressure limits in the design plan;
>
> (3) a decommissioned well. A well may experience a static positive pressure after shut down to accommodate for declining flows. All design changes shall be approved by the Administrator;
>
> **§60.753(c)** Operate each interior wellhead in the collection system with a landfill gas temperature less than 131 degrees Fahrenheit and with either a nitrogen level less than 20 percent or an oxygen level less than 5 percent. The owner or operator may establish a higher temperature, nitrogen or oxygen value at a particular well.

ADS – Zion Landfill received a determination by USEPA Region 5, dated April 4, 2008 approving alternate operational procedures for extraction points EW01, EW12A, EW164, CEW1W, CEW5, and CEW5E (letter to Laura Niemann of EIL, from George Czerniak): The facility received another determination by USEPA Region 5, dated October 3, 2008 approving alternative operational procedures for extraction points EW-02, EW-21 and EW-23 (letter to James Lewis of Zion Landfill, from George Czerniak). The letters are included in Appendix E of the updated GCCS plan for reference. Both USEPA letters approved the following alternative operational procedure:

1. When the oxygen concentration at the extraction location does not decline to acceptable levels after more than one hour of reduced vacuum, the location may be

shut off until the gas quality recovers.

2. The monthly monitoring required by 40 CFR Part 60, Subpart WWW will be conducted for these locations, but positive pressure or elevated oxygen concentrations will not be considered as exceedances of the operating limits in 40 CFR 60.753. However, the monthly monitoring results must be reported to the Illinois Environmental Protection Agency ("IEPA"). The reports to IEPA shall note if and when the extraction points are shut off in accordance with this letter.
3. If monthly monitoring indicates that pressure has built up in the extraction point and the oxygen concentration still exceeds 5 percent, the location will be briefly opened to relieve the pressure and may then be shut down until it is monitored the following month.
4. The surface monitoring required by 40 CFR Part 60, Subpart WWW will continue to be conducted in this area. Standard remediation steps, including evaluating the need to return the extraction location to full-time service, must be followed if exceedances of the 500 ppm methane surface concentration limits are detected in the immediate vicinity.
5. If the monthly monitoring indicates that gas quality has improved (i.e., the oxygen concentration has dropped below 5 percent), the extraction location will be brought back on line until the gas quality declines again. If the oxygen levels can be maintained below the regulatory limit of 5 percent, this alternate operating procedure is terminated and the well shall be operated in accordance with the regulatory requirements.

ADS - Zion Landfill has been following the USEPA's determination for the above mentioned extraction points since approval and is including this approved operational change within this updated GCCS plan. Please note that three extraction points (EW164, CEW1W & EW-23) of the above mentioned nine extraction points indicated on the USEPA's determination letters are no longer operational and have been either decommissioned or abandoned via a CAAPP Minor Modification, as directed by IEPA.

4.6.2.2 Early Installation of GCCS Extraction Components

> **§60.753(a)(1):** Operate the collection system such that gas is collected from each area, cell, or group of cells in the landfill in which solid waste has been in place for:
> 1. 5 years or more if active
> 2. 2 years or more if closed or at final grade

Permanent vertical wells will be installed once final grades are reached and the site is closed or at final grade for 2 years or more. For cells that have been active for 5 years or more and are not yet to final grades, vertical gas extraction wells, horizontal collection trenches and/or leachate collection system may be used for gas extraction. This alternative was approved by USEPA Region 7 for an NSPS landfill in Iowa on February 19, 2004 as long as it is included in the facility's GCCS Design Plan (Applicability Determination Index (ADI) Control No. 0400033).

At ADS - Zion Landfill, if the gas collection system is expanded into areas of the landfill that do not yet meet the above age criteria (for example, for odor control purposes), these wells will not be subject to the monthly monitoring requirements of the NSPS consistent with USEPA Applicability Determination No. 0800065. This is due to the fact that from a waste age standpoint, the area of the landfill where these wells have been placed is not yet subject to control.

4.6.2.3 Reduced Surface Scan Monitoring Frequency in Certified Closed Areas

> **§60.756(f):** Any closed landfill that has no monitored exceedances of the operational standard in three consecutive quarterly monitoring periods may skip to annual monitoring.

Consistent with USEPA Applicability Determination 0500087, ADS - Zion Landfill will reduce the surface monitoring frequency in certified closed areas of the landfill to an annual basis, once three clean consecutive quarters have been demonstrated in this closed area. At this time, this would include the closed Phase 1b,“old” Site 2 area, and cells 8A and 8B of the Site 2 expansion area of the landfill. The frequency will return to quarterly if a surface emissions exceedance of 500 ppm or more is detected, until such time as the site can demonstrate three consecutive quarters with no exceedances.

4.6.2.4 Areas with Steep Slopes or other Dangerous areas

> **§60.753(d):** “ A surface monitoring design plan shall be developed that includes a topographical map and the rationale for any site specific deviations from the 30 meter intervals. Areas with steep slopes or other dangerous areas may be excluded from surface testing”

In USEPA Applicability Determination No. 0400033, landfills may propose to exclude dangerous areas such as roads, the active area, truck traffic areas, construction areas, areas with snow or ice, and slopes steeper than or equal to 4:1 from surface testing as part of their GCCS design plan reviewed by the applicable state air agency. The actual monitoring route followed for each quarter, including area excluded and reasons for exclusion shall be included with each surface scan report.

4.6.2.5 Positive Pressure under Geosynthetic Capped Areas

> **§60.753(b)(2):** “Operate the collection system with negative pressure at each wellhead except under the following conditions:
>
> (1) A fire or increased well temperature. The owner or operator shall record instances when positive pressure occurs in efforts to avoid a fire. These records shall be submitted with the annual reports as provided in 60.757(f)(1);.
>
> **(2) Use of a geomembrane liner or synthetic cover. The owner or operator shall develop acceptable limits in the design plan.**

(3) A decommissioned well. A well may experience a static positive pressure after shut down to accommodate for declining flows. All design changes shall be approved by the Administrator.

An analysis was conducted to develop maximum allowable positive pressures for the wells at the ADS-Zion Landfill which will be located in areas of final cover with geosynthetic cap (see Appendix A-3). Based on this analysis, a maximum positive pressure of 26 inches water column (w.c.) at gas extraction wells in final cover areas with geomembrane is acceptable for the facility when the sideslope is 3:1. For areas of the site with a sideslope of 4:1, the maximum allowable positive pressure calculated increases to 39 inches w.c. The only part of the facility which will not have a geomembrane final cover component is a portion of Phase 1a.

Since the NSPS regulations specifically state that these limits need to be developed and presented in the Design Plan, and since approval of the Design Plan is a function of the delegated authority (IEPA), this positive pressure allowance does not require prior USEPA approval.

No other alternatives to the operational standards, test methods, procedures, compliance measures, monitoring, record keeping, or reporting provisions of §60.753 through §60.758 of the NSPS are proposed at this time.

4.6.3 Specifications for Active Collection Systems

As indicated in Sections 4.1 through 4.5 of this NSPS design plan, the GCCS proposed at the ADS - Zion Landfill complies with the specifications for active collection systems as listed in §60.759 of the NSPS. If revisions to or future expansions of the GCCS are necessary, they will be designed to comply with the NSPS requirements or any approved alternatives.

4.6.4 Install a Landfill Gas Collection and Control System

§60.752(b)(2)(ii) Install a collection and control system within 18 months of the submittal of the design plan under paragraph (b)(2)(i) of this section that effectively captures the gas generated within the landfill.

§60.752(b)(2)(ii)(A)(*2*) Collect gas from each area, cell, or group of cells in the landfill in which the initial solid waste has been placed for a period of:

§60.752(b)(2)(ii)(A)(*2*)(*i*) 5 years or more if active; or

§60.752(b)(2)(ii)(A)(*2*)(*ii*) 2 years or more if closed or at final grade;

The GCCS has been/will be constructed within the prescribed schedule under §60.752(b)(2)(ii). Future expansions to the GCCS will occur in accordance with the schedules under paragraphs (i) and (ii) of this section.

> **§60.752(b)(2)(ii)(A)(*3*)** Collect gas at a sufficient extraction rate;
>
> **§60.752(b)(2)(ii)(A)(*4*)** Be designed to minimize off-site migration of gas.

In accordance with §60.752(b)(2)(ii)(A)(*3*) and (*4*), the GCCS has been designed to extract LFG at a sufficient rate in order to minimize surface emissions and subsurface lateral migration of LFG. This is accomplished by sizing and installing collection elements at a sufficient density, correctly sizing transmission piping, blower(s), and LFG control equipment for the estimated maximum flow rate of LFG.

The GCCS is designed to collect LFG at a sufficient rate, which in accordance with the definition in §60.751 means to maintain a negative pressure at all wellheads without causing air infiltration. Application of a vacuum and minimization of air infiltration will be demonstrated by monthly monitoring of the static pressure and nitrogen or oxygen concentrations of the LFG at the extraction points.

Each extraction point will be monitored on a monthly basis in accordance with 40 CFR §60.753 (b) and (c), except where alternative monitoring has been approved. Monitoring will be performed for pressure, temperature, oxygen and/or nitrogen.

The installation and operation of an active gas recovery system causes an inward pressure gradient at the landfill, which will serve to minimize off-site migration of landfill gas. The facility performs perimeter gas monitoring in accordance with IEPA regulations. This monitoring will help to measure the effectiveness of the gas collection system at minimizing off-site migration.

4.6.5 Control Systems

> **§60.752(b)(2)(iii)**Route all the collected gas to a control system that complies with the requirements in either paragraph (b)(2)(iii)(A), (B) or (C) of this section.

The existing LFG control devices (five-engine landfill gas to energy plant, open flare and enclosed flare), currently have the ability to combust in excess of the predicted maximum gas flow rate from the permitted volume including the recently approved horizontal expansion.

40 CFR 60.752(b)(2)(iii)(A) requires that open flares used for control be designed and operated in accordance with 40 CFR 60.18. This includes no visible emissions, and criteria for minimum heating value of the fuel being burned, and exit velocity restrictions. The existing open flare (approved by IEPA via issuance of Construction

Permit No. 06100001) demonstrated that it met these criteria during its NSPS Initial Performance Test on May 23, 2007.

40 CFR §60.752(b)(2)(iii)(B) requires that "enclosed combustors", such as enclosed flares, be designed and operated to reduce the outlet NMOC concentration to 20 parts per million as hexane by volume, dry basis at 3 percent oxygen, or less. The facility demonstrated that the existing enclosed flare (approved by IEPA via issuance of Construction Permit No. 06100001) met these requirements during an Initial NSPS Performance Test on December 7, 2007.

Energy Development, Inc. (EDI), through its sister company, BioEnergy Illinois, LLC, owns and operates the five-engine gas to energy plant that utilizes landfill gas produced by ADS – Zion Landfill. The gas to energy plant is operated under a separate CAAPP Permit (# 097200ABC). The treatment process consists of compression, dewatering and filtration of the landfill gas. Treatment is one of the three allowable control methods of the NSPS. As stated previously in Section 2.2, the gas to energy plant received a Treatment Applicability determination from USEPA on August 11, 2004.

The expected maximum system gas flow rate at the ADS - Zion Landfill is projected to be 8,319 cfm. The existing open flare has a rated capacity of 3,000 scfm. The existing enclosed flare has a design capacity of 6,000 scfm. Each engine at the third party landfill gas to energy plant can combust approximately 580 scfm, for a plant-wide combustion total of 2,900 scfm. Total existing site combustion capacity is 11,900 scfm, which is more than adequate to combust the gas volumes currently collected as well as the future gas volumes anticipated from the recently approved expansion area. The number and type of control devices available provides backup capacity for routine or unforeseen downtime.

Gas mover equipment at the ADS - Zion Landfill consists of two 150 Hp centrifugal multistage blowers which feed the enclosed flare and/or LFGTE plant at the west side of the site. These blowers can each move 3,000 scfm of gas, and can apply up to 100 inches w.c. of vacuum on the landfill. The open flare has a 75 Hp blower that can handle up to 3,000 scfm of landfill gas flow, with 58 inches w.c. applied vacuum and is located approximately mid-way along the north side of the site. The LFGTE plant is equipped with positive displacement blowers that could also be utilized to pull gas from the landfill to the plant to supply the engines, if needed. The facility therefore has sufficient gas mover equipment to manage the expected maximum volume of gas from the landfill including the recently approved expansion.

Appendix A

APPENDIX A

CALCULATIONS

APPENDIX A-1 GAS GENERATION RATE MODELING

APPENDIX A-2 RADIUS OF INFLUENCE AND WELL SPACING CALCULATIONS

APPENDIX A-3 POSITIVE PRESSURE ALLOWANCES

APPENDIX A-1

GAS GENERATION RATE MODELING

INTRODUCTION

The NSPS states that "gas mover equipment... be sized to handle the maximum gas generation flow rate expected over the intended use period of the gas moving equipment" (40 CFR 60.759[c]). This calculation of maximum gas flow rate for the ADS - Zion Landfill is split into three components based on waste type and current status of the landfill area (i.e., closed or active):

- Closed Phase 1a co-disposal area
- Closed Phase 1b/Site 2 MSW area
- Current active Site 2 Expansion & Site 2 East Vertical/Horizontal Expansion area

A calculation to estimate the maximum gas generation flow rate from these areas must be performed in accordance with 40 CFR 60.755(a)(1). The following equation was utilized for calculating the maximum gas flow rate for the ADS - Zion Landfill:

$$Q_M = \sum_{i=1}^{n} 2k\, L_o\, M_i\, (e^{-kti})$$

Where: Q_M = maximum expected gas generation flow rate, cubic meters per year

k = methane generation rate constant, year $^{-1}$

L_o = methane generation potential, cubic meters per megagram solid waste

M_i = mass of solid waste in the i^{th} section, megagrams

t_i = age of the i^{th} section, years

The NSPS states that the k and L_o kinetic factors "should be those published in the most recent compilation of Air Pollutant Emission Factors (AP-42) or other site specific values demonstrated to be appropriate and approved by the Administrator." For a portion of the site, the facility is requesting the ability to use kinetic factors from a database compiled by EIL. The database contains gas generation rates measured from over two dozen landfills during gas extraction tests conducted in the mid to late 1980s. The landfills were sited across varying geographical regions of the United States in order to assess the effect of location and climate on gas generation rates. Data on these gas extraction tests was provided to the EPA's Office of Air Quality Planning and Standards in 1988 and 1989 as background information for the development of the NSPS. The gas extraction tests conducted at the landfills in the 1980s are very similar to the Tier III testing described in the NSPS.

A summary of the database is provided in Table 3. The selection of appropriate kinetic factors for the facility is discussed in the next subsection.

SELECTION OF EQUATION PARAMETERS

Methane Generation Rate Constant k:

The closed Phase 1a co-disposal area and the closed Phase 1b/Old Site 2 areas did not recirculate leachate during filling operations. Landfill gas temperatures measured at these wells are generally less than 110 degrees Fahrenheit, which indicates that the methanogenic process is mesophilic. The type of microbial environment has an impact on design considerations as well as determining an appropriate gas generation rate. Landfills that exhibit mesophilic characteristics have a slightly lower gas generation rate. A gas generation rate of 0.108 cubic feet per pound of refuse per year most closely approximates the rate that is collected from these closed areas of the ADS - Zion Landfill. In order to convert the gas generation rate to the methane generation rate constant k, the gas generate rate is divided by the theoretical landfill gas yield per pound of refuse (as discussed in the next subsection). This results in a k value of 0.024 year^{-1} for the closed Phase 1a and Phase 1b/Old Site 2.

For the active Site 2 expansion & Site 2 East Vertical/Horizontal expansion area, the value used for the methane generation rate constant k was obtained from AP-42 (Fifth Edition, Volume 1, Chapter 2.4). It was assumed that k = 0.04 year^{-1}. This higher k value is appropriate since the site periodically recirculates leachate within this section of the landfill. The addition of liquids has been shown to result in a higher gas generation rate.

Methane Generation Potential L_o:
The next input into the gas flow rate equation is the theoretical maximum yield (expected volume of gas per unit mass of refuse). Determining the maximum theoretical yield of a unit mass of municipal solid waste is a difficult task. Either of two methods can be used: 1) stoichiometric, or 2) biodegradability, but both methods require extensive sampling, time-consuming lab analyses, and difficult concise analytical procedures. Both methods also rely extensively on a characteristic sample of the waste stream. Most samples, however, are small in size relative to the composite waste stream and often are not very characteristic of the biodegradability of the waste. In an evaluation of this nature, it is not practical to place much emphasis on characterizing the organic fraction of the waste stream unless large samples are collected.

Based on past experience, which included an extensive literature review and a review of data available on the typical United States waste stream, a theoretical yield of **4.5 cubic feet per pound of refuse** was derived for the majority of the facility (i.e. closed Phase 1b/Old Site 2 area, active Site 2 & Site 2 East Vertical/Horizontal expansion area). This value closely approximates observed landfill gas production in sites of similar characteristics.

In order to utilize theoretical yield (or “methane generation potential”) in the gas generation equation, the value must be reported in terms of cubic meters of methane per megagram of solid waste rather than cubic feet of landfill gas per pound of refuse. After converting from English to metric units, and assuming that approximately 50 percent of landfill gas is comprised of methane, an L_o value of 139.6 m^3/methane/megagram solid waste was derived.

The Phase 1a co-disposal area did not contain as much MSW waste as the remainder of the facility. Since there was less MSW, the value used for Lo was obtained from AP-42 (Fifth Edition, Volume 1, Chapter 2.4). It was assumed that Lo = 100 m^3 methane/megagram solid waste in this section of the landfill.

Mass of Solid Waste M_i:

The gas production volume for the facility was based on estimated gate receipts from 1975 to 1995, actual waste receipts from 1998 to 2013 and future gas receipts predicted for the years 2014 through 2023.

This data forms the foundation of the gas volume projection and is subject to change over the active lifetime of the landfill. It also implies that the gas volume projection will vary accordingly. This variability does not pose a problem with gas management system design. The gas management system design at the ADS - Zion Landfill is based on the expected gas production from the planned volumetric space of the landfill. Therefore, even though gas volumes may fluctuate over a period of time because of varying disposal rates, the ultimate total volume of gas projected for the site will remain constant and the gas collection system components will be sized accordingly.

Waste intake volumes are provided in Table 4.

Age of the "i^{th} section", t_i:

This age is automatically calculated with each iteration of the EPA model.

CALCULATION OF MAXIMUM GAS GENERATION RATE

The EPA has simplified the gas generation rate calculation by providing an Excel-based program to the public. Therefore, the EPA's Landfill Air Emissions Estimation Model was utilized to predict maximum landfill gas generation volumes. The model output provides an estimation of total gas production volume.

Based on the model output provided in Attachments 1 - 3, and the annual sum of the individual flow rates from each area provided in Table 3, the following maximum gas generation flow rate was estimated for the year 2024 for the ADS - Zion Landfill:

Total LFG Production = 8,319 ft^3/min

The average collected flow rate reported by the site in 2014, approximately 3,800 scfm, compares well (based on a typical gas collection efficiency of 75-80%) to the modeled combined value in 2014 of 4,695 scfm.

Table 3: Database of Landfill Gas Generation Rates

Site ID	State	Measured Gas Generation Rate (ft^3/lb/yr)	Corresponding "k" Value (1/yr)*
A	Pennsylvania	.130	.029
B	Wisconsin	.126	.028
C	Wisconsin	.079	.018
D	Ohio	.116	.026
E	Michigan	.112	.025
F	Illinois	.130	.029
G	Colorado	.06	.013
H	Florida	.172	.038
I	New Jersey	.085	.019
J	New Jersey	.098	.022
K	New York	.147	.033
L	Texas	.112	.025
M	Colorado	.085	.019
N	Connecticut	.159	.035
O	Pennsylvania	.042	.009
P	Illinois	.124	.028
Q	California	.083	.018
R	Illinois	.142	.032
S	Texas	.095	.021
T	Kentucky	.108	.024
U	California	.065	.014
V	Maryland	.063	.014
W	New York	.094	.021
X	Ohio	.089	.02
Y	Ohio	.096	.021
Z	Ohio	.082	.018
AA	Massachusetts	.104	.023
BB	Ohio	.067	.015
CC	New Hampshire	.102	.023
DD	Illinois	.085	.019
EE	California	.109	.024
FF	Illinois	.075	.017

* k values were calculated by dividing the gas generation rate by the theoretical maximum gas production of 4.5 ft^3 landfill gas/lb of refuse.

TABLE 4: ANNUAL WASTE RECIEPTS (MG)

YEAR	CLOSED PHASE 1A CO-DISPOSAL*	CLOSED MSW*	ACTIVE SITE 2 & SITE EAST HORIZONTAL/VERTICAL EXPANSION	TOTAL
1975	90,288			90,288
1976	90,288			90,288
1977	90,288			90,288
1978	90,288			90,288
1979	90,288			90,288
1980	90,288	149,687		239,975
1981	90,288	149,687		239,975
1982	90,288	149,687		239,975
1983	90,288	149,687		239,975
1984	90,288	149,687		239,975
1985	90,288	149,687		239,975
1986	90,288	149,687		239,975
1987	90,288	149,687		239,975
1988	90,288	149,687		239,975
1989	90,288	149,687		239,975
1990	90,288	149,687		239,975
1991	90,288	149,687		239,975
1992	90,288	149,687		239,975
1993	90,288	149,687		239,975
1994	90,288	149,687		239,975
1995	90,288	149,687		239,975
1996				0
1997				0
1998			298,213	298,213
1999			468,887	468,887
2000			475,370	475,370
2001			476,415	476,415
2002			503,280	503,280
2003			555,017	555,017
2004			545,262	545,262
2005			531,824	531,824
2006			517,021	517,021
2007			515,482	515,482
2008			438,738	438,738
2009			404,301	404,301
2010			214,576	214,576
2011			294,481	294,481
2012			352,990	352,990
2013			369,156	369,156
2014			806,000	806,000
2015			757,636	806,000

YEAR	CLOSED PHASE 1A CO-DISPOSAL*	CLOSED MSW*	ACTIVE SITE 2 & SITE EAST HORIZONTAL/VERTICAL EXPANSION	TOTAL
2016			806,000	806,000
2017			806,000	806,000
2018			806,000	806,000
2019			806,000	806,000
2020			806,000	806,000
2021			806,000	806,000
2022			806,000	806,000
2023			933,455	885,091

*Waste volumes are estimated since actual waste receipt volumes are not available.

TABLE 5: TOTAL PROJECTED MAXIMUM GAS FLOW RATE (scfm)

YEAR	CLOSED PHASE 1A CO-DISPOSAL	CLOSED MSW	ACTIVE SITE 2 & SITE EAST HORIZONTAL/VERTICAL EXPANSION	TOTAL
1975	0	0	0	0
1976	29	0	0	29
1977	57	0	0	57
1978	84	0	0	84
1979	111	0	0	111
1980	137	0	0	137
1981	163	67	0	230
1982	188	132	0	320
1983	212	195	0	407
1984	236	257	0	493
1985	259	318	0	577
1986	282	377	0	659
1987	304	435	0	739
1988	326	491	0	817
1989	347	546	0	893
1990	367	600	0	967
1991	387	652	0	1,039
1992	407	704	0	1,111
1993	426	754	0	1,180
1994	445	802	0	1,247
1995	463	850	0	1,313
1996	481	896	0	1,377
1997	469	875	0	1,344
1998	458	854	0	1,312
1999	447	834	220	1,501
2000	437	814	558	1,809
2001	427	795	888	2,110
2002	416	776	1,205	2,397
2003	407	758	1,530	2,695
2004	397	740	1,880	3,017
2005	387	722	2,209	3,318
2006	378	705	2,516	3,599
2007	369	688	2,799	3,856
2008	361	672	3,071	4,104
2009	352	656	3,275	4,283
2010	344	641	3,446	4,431
2011	336	625	3,469	4,430
2012	328	611	3,550	4,489
2013	320	596	3,672	4,588

YEAR	CLOSED PHASE 1A CO-DISPOSAL	CLOSED MSW	ACTIVE SITE 2 & SITE EAST HORIZONTAL/VERTICAL EXPANSION	TOTAL
2014	312	582	3,801	4,695
2015	305	568	4,248	5,121
2016	298	555	4,677	5,530
2017	291	542	5,089	5,922
2018	284	529	5,485	6,298
2019	277	516	5,866	6,659
2020	270	504	6,232	7,006
2021	264	492	6,583	7,339
2022	258	480	6,921	7,659
2023	252	469	7,245	7,966
2024	**246**	**458**	**7,615**	**8,319**
2025	240	447	7,317	8,004
2026	234	436	7,030	7,700
2027	229	426	6,754	7,409
2028	223	416	6,489	7,128
2029	218	406	6,235	6,859
2030	213	396	5,990	6,599

ATTACHMENT 1: Closed Phase 1a LandGEM Model Output

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1975**	
Landfill Closure Year (with 80-year limit)	**1995**	

MODEL PARAMETERS

Methane Generation Rate, k	**0.024**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**100**	*m^3/Mg*
NMOC Concentration	**2,400**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1975	90,288	99,316	0	0
1976	90,288	99,316	90,288	99,316
1977	90,288	99,316	180,575	198,633
1978	90,288	99,316	270,863	297,949
1979	90,288	99,316	361,150	397,265
1980	90,288	99,316	451,438	496,582
1981	90,288	99,316	541,725	595,898
1982	90,288	99,316	632,013	695,214
1983	90,288	99,316	722,301	794,531
1984	90,288	99,316	812,588	893,847
1985	90,288	99,316	902,876	993,163
1986	90,288	99,316	993,163	1,092,480
1987	90,288	99,316	1,083,451	1,191,796
1988	90,288	99,316	1,173,739	1,291,112
1989	90,288	99,316	1,264,026	1,390,429
1990	90,288	99,316	1,354,314	1,489,745
1991	90,288	99,316	1,444,601	1,589,061
1992	90,288	99,316	1,534,889	1,688,378
1993	90,288	99,316	1,625,176	1,787,694
1994	90,288	99,316	1,715,464	1,887,010
1995	90,288	99,316	1,805,752	1,986,327
1996	0	0	1,896,039	2,085,643

Results

Year	Total landfill gas		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*
1975	0	0	0
1976	5.354E+02	4.287E+05	2.881E+01
1977	1.058E+03	8.473E+05	5.693E+01
1978	1.568E+03	1.256E+06	8.439E+01
1979	2.067E+03	1.655E+06	1.112E+02
1980	2.553E+03	2.044E+06	1.374E+02
1981	3.028E+03	2.425E+06	1.629E+02
1982	3.492E+03	2.796E+06	1.879E+02
1983	3.944E+03	3.158E+06	2.122E+02
1984	4.386E+03	3.512E+06	2.360E+02
1985	4.817E+03	3.858E+06	2.592E+02
1986	5.239E+03	4.195E+06	2.819E+02
1987	5.650E+03	4.524E+06	3.040E+02
1988	6.051E+03	4.846E+06	3.256E+02
1989	6.443E+03	5.159E+06	3.467E+02
1990	6.826E+03	5.466E+06	3.672E+02
1991	7.199E+03	5.765E+06	3.873E+02
1992	7.564E+03	6.057E+06	4.070E+02
1993	7.920E+03	6.342E+06	4.261E+02
1994	8.268E+03	6.620E+06	4.448E+02
1995	8.607E+03	6.892E+06	4.631E+02
1996	8.938E+03	7.157E+06	4.809E+02
1997	8.726E+03	6.988E+06	4.695E+02
1998	8.519E+03	6.822E+06	4.584E+02
1999	8.317E+03	6.660E+06	4.475E+02
2000	8.120E+03	6.502E+06	4.369E+02
2001	7.928E+03	6.348E+06	4.265E+02
2002	7.740E+03	6.197E+06	4.164E+02
2003	7.556E+03	6.051E+06	4.065E+02
2004	7.377E+03	5.907E+06	3.969E+02
2005	7.202E+03	5.767E+06	3.875E+02
2006	7.031E+03	5.630E+06	3.783E+02
2007	6.864E+03	5.497E+06	3.693E+02
2008	6.702E+03	5.366E+06	3.606E+02
2009	6.543E+03	5.239E+06	3.520E+02
2010	6.388E+03	5.115E+06	3.437E+02
2011	6.236E+03	4.994E+06	3.355E+02

Year	Total landfill gas		
	(Mg/year)	***(m^3/year)***	***(av ft^3/min)***
2012	6.088E+03	4.875E+06	3.276E+02
2013	5.944E+03	4.760E+06	3.198E+02
2014	5.803E+03	4.647E+06	3.122E+02
2015	5.665E+03	4.536E+06	3.048E+02
2016	5.531E+03	4.429E+06	2.976E+02
2017	5.400E+03	4.324E+06	2.905E+02
2018	5.272E+03	4.221E+06	2.836E+02
2019	5.147E+03	4.121E+06	2.769E+02
2020	5.025E+03	4.023E+06	2.703E+02
2021	4.905E+03	3.928E+06	2.639E+02
2022	4.789E+03	3.835E+06	2.577E+02
2023	4.676E+03	3.744E+06	2.516E+02
2024	4.565E+03	3.655E+06	2.456E+02
2025	4.456E+03	3.568E+06	2.398E+02
2026	4.351E+03	3.484E+06	2.341E+02
2027	4.248E+03	3.401E+06	2.285E+02
2028	4.147E+03	3.321E+06	2.231E+02
2029	4.048E+03	3.242E+06	2.178E+02
2030	3.952E+03	3.165E+06	2.127E+02

ATTACHMENT 2: Closed Phase 1b/Old Site 2 LandGEM Model Output

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1980**	
Landfill Closure Year (with 80-year limit)	**1995**	

MODEL PARAMETERS

Methane Generation Rate, k	**0.024**	*year^{-1}*
Potential Methane Generation Capacity, L_o	**140**	*m^3/Mg*
NMOC Concentration	**600**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1980	149,687	164,656	0	0
1981	149,687	164,656	149,687	164,656
1982	149,687	164,656	299,374	329,311
1983	149,687	164,656	449,061	493,967
1984	149,687	164,656	598,748	658,623
1985	149,687	164,656	748,435	823,279
1986	149,687	164,656	898,122	987,934
1987	149,687	164,656	1,047,809	1,152,590
1988	149,687	164,656	1,197,496	1,317,246
1989	149,687	164,656	1,347,183	1,481,901
1990	149,687	164,656	1,496,870	1,646,557
1991	149,687	164,656	1,646,557	1,811,213
1992	149,687	164,656	1,796,244	1,975,869
1993	149,687	164,656	1,945,931	2,140,524
1994	149,687	164,656	2,095,618	2,305,180
1995	149,687	164,656	2,245,305	2,469,836
1996	0	0	2,394,992	2,634,492

Results

Year	Total landfill gas		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*
1980	0	0	0
1981	1.239E+03	9.923E+05	6.667E+01
1982	2.449E+03	1.961E+06	1.318E+02
1983	3.630E+03	2.907E+06	1.953E+02
1984	4.783E+03	3.830E+06	2.573E+02
1985	5.909E+03	4.732E+06	3.179E+02

Year	Total landfill gas		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*
1986	7.008E+03	5.612E+06	3.770E+02
1987	8.081E+03	6.471E+06	4.348E+02
1988	9.128E+03	7.310E+06	4.911E+02
1989	1.015E+04	8.129E+06	5.462E+02
1990	1.115E+04	8.928E+06	5.999E+02
1991	1.212E+04	9.709E+06	6.523E+02
1992	1.308E+04	1.047E+07	7.035E+02
1993	1.401E+04	1.121E+07	7.535E+02
1994	1.491E+04	1.194E+07	8.023E+02
1995	1.580E+04	1.265E+07	8.500E+02
1996	1.666E+04	1.334E+07	8.965E+02
1997	1.627E+04	1.303E+07	8.752E+02
1998	1.588E+04	1.272E+07	8.545E+02
1999	1.550E+04	1.242E+07	8.342E+02
2000	1.514E+04	1.212E+07	8.144E+02
2001	1.478E+04	1.183E+07	7.951E+02
2002	1.443E+04	1.155E+07	7.762E+02
2003	1.409E+04	1.128E+07	7.578E+02
2004	1.375E+04	1.101E+07	7.399E+02
2005	1.343E+04	1.075E+07	7.223E+02
2006	1.311E+04	1.050E+07	7.052E+02
2007	1.280E+04	1.025E+07	6.885E+02
2008	1.249E+04	1.000E+07	6.721E+02
2009	1.220E+04	9.766E+06	6.562E+02
2010	1.191E+04	9.535E+06	6.406E+02
2011	1.162E+04	9.309E+06	6.254E+02
2012	1.135E+04	9.088E+06	6.106E+02
2013	1.108E+04	8.872E+06	5.961E+02
2014	1.082E+04	8.662E+06	5.820E+02
2015	1.056E+04	8.457E+06	5.682E+02
2016	1.031E+04	8.256E+06	5.547E+02
2017	1.007E+04	8.060E+06	5.416E+02
2018	9.827E+03	7.869E+06	5.287E+02
2019	9.594E+03	7.682E+06	5.162E+02
2020	9.367E+03	7.500E+06	5.039E+02
2021	9.144E+03	7.322E+06	4.920E+02
2022	8.928E+03	7.149E+06	4.803E+02
2023	8.716E+03	6.979E+06	4.689E+02
2024	8.509E+03	6.814E+06	4.578E+02

Year	Total landfill gas		
	(Mg/year)	***(m³/year)***	***(av ft^3/min)***
2025	8.307E+03	6.652E+06	4.470E+02
2026	8.110E+03	6.494E+06	4.364E+02
2027	7.918E+03	6.340E+06	4.260E+02
2028	7.730E+03	6.190E+06	4.159E+02
2029	7.547E+03	6.043E+06	4.060E+02
2030	7.368E+03	5.900E+06	3.964E+02

ATTACHMENT 3: Active Site 2 & Site 2 East Expansion Area LandGEM Model Output

Input Review

LANDFILL CHARACTERISTICS

Landfill Open Year	**1998**	
Landfill Closure Year (with 80-year limit)	**2023**	

MODEL PARAMETERS

Methane Generation Rate, k	**0.040**	*$year^{-1}$*
Potential Methane Generation Capacity, L_o	**140**	*m^3/Mg*
NMOC Concentration	**800**	*ppmv as hexane*
Methane Content	**50**	*% by volume*

WASTE ACCEPTANCE RATES

Year	Waste Accepted		Waste-In-Place	
	(Mg/year)	*(short tons/year)*	*(Mg)*	*(short tons)*
1998	298,213	328,034	0	0
1999	468,887	515,776	298,213	328,034
2000	475,370	522,907	767,100	843,810
2001	476,415	524,056	1,242,469	1,366,716
2002	503,280	553,608	1,718,884	1,890,773
2003	555,017	610,518	2,222,165	2,444,381
2004	545,262	599,788	2,777,181	3,054,899
2005	531,824	585,007	3,322,443	3,654,687
2006	517,021	568,724	3,854,267	4,239,694
2007	515,482	567,030	4,371,289	4,808,418
2008	438,738	482,612	4,886,770	5,375,447
2009	404,301	444,731	5,325,509	5,858,060
2010	214,576	236,034	5,729,810	6,302,791
2011	294,481	323,929	5,944,386	6,538,824
2012	352,990	388,289	6,238,867	6,862,753
2013	369,156	406,072	6,591,857	7,251,042
2014	806,000	886,600	6,961,013	7,657,114
2015	806,000	886,600	7,767,013	8,543,714
2016	806,000	886,600	8,573,013	9,430,314
2017	806,000	886,600	9,379,013	10,316,914
2018	806,000	886,600	10,185,013	11,203,514
2019	806,000	886,600	10,991,013	12,090,114
2020	806,000	886,600	11,797,013	12,976,714
2021	806,000	886,600	12,603,013	13,863,314
2022	806,000	886,600	13,409,013	14,749,914
2023	885,091	973,600	14,215,013	15,636,514
2024	0	0	15,100,104	16,610,114

Results

Year	Total landfill gas		
	(Mg/year)	*(m^3/year)*	*(av ft^3/min)*
1998	0	0	0
1999	4.097E+03	3.281E+06	2.204E+02
2000	1.038E+04	8.310E+06	5.584E+02
2001	1.650E+04	1.321E+07	8.878E+02
2002	2.240E+04	1.794E+07	1.205E+03
2003	2.844E+04	2.277E+07	1.530E+03
2004	3.495E+04	2.798E+07	1.880E+03
2005	4.107E+04	3.288E+07	2.209E+03
2006	4.676E+04	3.745E+07	2.516E+03
2007	5.203E+04	4.166E+07	2.799E+03
2008	5.707E+04	4.570E+07	3.071E+03
2009	6.086E+04	4.874E+07	3.275E+03
2010	6.403E+04	5.127E+07	3.445E+03
2011	6.447E+04	5.162E+07	3.469E+03
2012	6.599E+04	5.284E+07	3.550E+03
2013	6.825E+04	5.465E+07	3.672E+03
2014	7.064E+04	5.657E+07	3.801E+03
2015	7.895E+04	6.322E+07	4.248E+03
2016	8.692E+04	6.960E+07	4.677E+03
2017	9.459E+04	7.574E+07	5.089E+03
2018	1.020E+05	8.164E+07	5.485E+03
2019	1.090E+05	8.730E+07	5.866E+03
2020	1.158E+05	9.275E+07	6.232E+03
2021	1.224E+05	9.798E+07	6.583E+03
2022	1.286E+05	1.030E+08	6.921E+03
2023	1.347E+05	1.078E+08	7.245E+03
2024	1.415E+05	1.133E+08	7.615E+03
2025	1.360E+05	1.089E+08	7.317E+03
2026	1.307E+05	1.046E+08	7.030E+03
2027	1.255E+05	1.005E+08	6.754E+03
2028	1.206E+05	9.658E+07	6.489E+03
2029	1.159E+05	9.279E+07	6.235E+03
2030	1.113E+05	8.916E+07	5.990E+03

APPENDIX A-2

RADIUS OF INFLUENCE AND WELL SPACING CALCULATIONS

INTRODUCTION

One of the first steps in performing a gas system design is to lay out the location of the vertical gas extraction wells. The spacing (or horizontal distance) between the wells is determined by a calculated "Radius of Influence" (ROI). The ROI defines an area from which gas can be extracted without inducing excessive air into the landfill. General design criteria, the method for determining ROIs and well construction are discussed in the following subsections.

Well spacing is also the first requirement listed under 40 CFR 60.759: Specifications for Active Collection Systems. Specifically, each owner or operator seeking to comply with §60.752(b)(i) should site active collection wells, horizontal collectors, surface collectors, or other extraction devices at a sufficient density throughout all gas producing areas using the following procedures unless alternative procedures have been approved by the Administrator.

A complete gas collection system has already been installed over the closed Phase 1a, closed Phase 1b/Old Site 2, and portions of the active Site 2 and Site 2 East Vertical/Horizontal expansion area. As-builts of the system are included in Appendix C. The adequacy of spacing for these existing wells is demonstrated by periodic surface scans conducted in accordance with the NSPS.

A conceptual design for the future wells to be installed in the expansion area was prepared and drawings are included in Appendix C. The actual number and location of wells may vary from this design based on field conditions. A discussion on the methodology used to calculate well density for the new expansion area is provided below.

DESIGN METHODOLOGY: DARCY RADIUS OF INFLUENCE

The correct placement of vertical gas extraction wells is a critical component of the landfill gas control system design. The goal is to maximize the volume of gas extracted from the landfill without harming the landfill environment. Maximizing the volume of methane gas extracted will help minimize landfill emissions, reduce the occurrence of odors, minimize vegetative stress, and control potential subsurface gas migration.

When a well is placed under a vacuum, or negative pressure, the recoverable landfill gas in the immediate vicinity will begin to move towards it. This area of gas movement is called a well's "Radius of Influence", or ROI. For ease of calculation, the area is assumed to be cylindrical with the vertical well in the center of the cylinder. The edge of the ROI is reached when the pull of vacuum exerted by the well is zero; i.e., landfill gas will no longer move towards the well from beyond a certain point. The actual extent of influence will vary from well to well. However, for design purposes, a theoretical ROI can be calculated based on certain assumptions made about the well and its surrounding refuse environment. The factors which influence a well's ROI include:

- the depth of the well
- the length of slotted pipe provided for gas collection

- the rate of gas generation in the refuse
- the refuse temperature
- the amount of vacuum applied to the well
- the density of the waste

The movement of landfill gas through refuse is essentially the movement of a fluid through a porous media, which can be estimated using a modified form of Darcy's equation for radial fluid flow. A computer spreadsheet has been developed which incorporates the Darcy equation to calculate a theoretical ROI for each well.

The designer enters the site-specific information for the conceptual gas extraction system into the spreadsheet. The results allow the designer to space the gas extraction wells with an optimum amount of overlap, so that all areas of the landfill are theoretically covered. The data for the wells proposed for the ADS – Zion Landfill Site 2 East Horizontal Expansion is shown on Table 6.

GENERAL ASSUMPTIONS

The careful formulation of assumptions for the spreadsheet is critical to the accuracy of the program's output, and requires some knowledge of the landfill's characteristics. A discussion of each assumption follows:

Gas Generation Rate:

Landfill gas is the by-product of the anaerobic decomposition of organic material disposed of in a landfill, by methanogenic (methane producing) bacteria. Landfill gas production is assumed to have a first order reaction rate and is dependent upon the following:

- age of the landfill & types of waste received
- location (i.e., climate and precipitation)
- moisture conditions within the refuse
- landfill cover materials and thicknesses

As discussed previously, a k value of 0.04 year^{-1} was obtained from AP-42. To convert this to English units for use in the ROI program, the k value must be multiplied by the theoretical yield. The theoretical yield is assumed to be 139.6 m^3 methane/Mg waste, which converts to 4.5 ft^3 LFG/lb waste. The gas generation rate is therefore 0.18 ft^3 LFG/lb refuse/year.

Permeability Factor:

Permeability is defined as a measure of the ability of a porous media to transmit fluids. While the permeability of refuse within a landfill can vary greatly, it is assumed to be a constant for ease of calculation in the spreadsheet. A reasonable absolute permeability value for refuse is 2.286×10^{-11} (ft^2). This number was calculated by applying Darcy's Law for Linear

Compressible Fluid Flow to the movement of landfill gas through refuse and assuming the following:

1. Steady state flow conditions exist.
2. The pore space of the refuse is 100 percent saturated with the flowing fluid (landfill gas).
3. The viscosity of the flowing fluid is constant.
4. Isothermal conditions in the refuse prevail.
5. Flow is laminar, horizontal and linear since refuse grain size is relatively small and the velocity of fluid flow is low.

Refuse Density:

Refuse density is a function of the types of waste received and the degree of compaction at the landfill site. A refuse density of 2,025 lbs/yd^3 (75.0 lbs/ft^3) was used for the calculations.

Gas Temperature:

The temperatures within a landfill can influence the movement of landfill gas in two ways. First, since landfill gas is a compressible fluid, its viscosity and flow characteristics must be corrected to standard temperature and pressure conditions prior to using the Darcy Equation for radial fluid flow. A discussion of this is included in Attachment 4, which presents the derivation of Darcy's equation for landfill gas flow.

Secondly, a landfill's interior temperature can affect the rate at which landfill gas is generated since different types of bacteria are present at different temperatures. Methanogens (or methane producing bacteria) that generate landfill gas at temperatures below 110°F are known as mesophilic bacteria, while those that generate gas at temperatures in excess of 110°F are called thermophilic bacteria. A gas temperature of 100°F was used in the ROI spreadsheet based on a review of typical well temperatures within the existing wells at the facility.

Average Cover Depth:

The average thickness of final or intermediate cover over the waste at the time of well installation is subtracted from the refuse depth available for gas production. Soil is inert and will not contribute to the generation of landfill gas.

Average Maximum Radius of Influence:

A default maximum ROI of 225 feet was calculated for the facility, since the final cover will incorporate a geosynthetic membrane. If the Darcy equation calculates a radius of influence greater than 225 feet, the default maximum will be used. Even though the limiting ROI assumption was applied for the purposes of this calculation, well specific ROI’s were generated and used as the basis for the proposed well layout.

Average Overlap Factor:

When the gas system designer plots the well locations on a landfill's topographic map and draws the calculated ROIs around each well, it is desirable to achieve a certain degree of overlap of the circular ROIs. Since the calculations are theoretical to begin with, the overlap provides a factor of safety to the gas control system design. If field conditions prevent gas from moving towards a particular well, an overlap helps ensure that the gas can travel to more than one collection point.

WELL CONSTRUCTION

Description of Vertical Gas Wells:

A typical gas well proposed for installation at the facility is included in Appendix C. Materials of construction are indicated on the details. As indicated previously, the facility may employ a variety of collection methods in order to extract landfill gas. As-built drawings of the collection system will be kept on site in the NSPS files, as required by the regulation.

Prior to installation of the vertical gas extraction wells, the actual ground surface is surveyed and the as-built liner base grades checked to insure that the drilling of the well will not perforate the liner. The drilling depth for new gas wells will terminate at least 10 feet above the landfill’s base liner, in order to avoid liner penetration.

If liquids encountered during drilling impede the completion of a particular well, the driller will move the borehole over a few feet. Base grades will be re-checked prior to drilling. If liquids begin to accumulate in a well over time, the facility may install a pumping system. There are several wells at the facility which are currently equipped with liquid removal pumps.

NSPS Compliance:

The proposed gas collection wells will meet the following requirements listed in 40 CFR 60.759:

- minimization of air intrusion
- waste depths and proper connector assembly (closing valves, sampling ports, etc.).
- required materials of construction and granular fill dimensions
- corrosion resistance
- sufficient density of extraction devices
- avoidance of damage to underlying liners
- occurrence of water within the landfill

TABLE 6: Radius of Influence Calculation Table

DATE: December 3, 2014
PROJ. NO:
PROJECT: ADS - Zion Landfill
LOCATION: Zion, Illinois
BY: CJN

AVERAGE ASSUMPTIONS

GAS GENERATION RATE:	0.180	FT3/LBm*YR
PERMEABILITY FACTOR:	2.286	x 10E-11, FT2
REFUSE DENSITY:	75.00	LBm/FT3
GAS TEMPERATURE:	100	DEG. F
COVER DEPTH:	5	FT
DESIGN MAX. ROI:	225	FT
OVERLAP FACTOR:	15	%

Assumes standard conditions are 14.7 psia, 60 Deg. F.

WELL NO.	Well COORDINATES NORTH	EAST	SURFACE ELEVATION (FASL)	BASE ELEVATION* (FASL)	DEPTH OFF BASE (FT)	WELL DEPTH (FT)	LENGTH OF PIPE SOLID (FT)	SLOTTED (FT)	(Hs/Ht) RATIO	APPLIED VACUUM (in WC)	ROI (FT)
EW-152R	11646.58	11955.81	922.07	696.45	10	180	20	160	0.89	7.50	162
EW-153R	11888.15	11966.13	894.89	689.88	10	180	20	160	0.89	7.50	162
EW-156	12334.05	12223.84	782.44	702.00	10	70	20	50	0.72	7.50	146
EW-157	12121.57	12250.19	835.45	687.85	10	138	20	118	0.85	7.50	159
EW-158R	11842.86	12258.91	905.09	690.98	10	180	20	160	0.89	7.50	162
EW-159R	11567.26	12179.69	914.50	722.00	10	180	20	160	0.89	7.50	162
EW-160R	11590.47	12423.90	900.00	695.00	10	180	20	160	0.89	7.50	162
EW-161R	11881.07	12466.58	888.23	689.00	10	180	20	160	0.89	7.50	162
EW-162R	12105.52	12467.73	838.63	687.00	10	142	20	122	0.86	7.50	160
EW-163	12319.73	12451.59	785.15	697.50	10	78	20	58	0.74	7.50	148
EW-170	12041.92	12905.08	778.79	701.00	10	68	20	48	0.70	7.50	145
EW-171	11791.92	12905.08	779.02	702.00	10	67	20	47	0.70	7.50	144
EW-172	11541.92	12905.08	780.14	703.00	10	67	20	47	0.70	7.50	144
EW-173	11291.92	12905.08	781.25	704.00	10	67	20	47	0.70	7.50	144
EW-174	11060.70	12810.44	779.77	709.00	10	61	20	41	0.67	7.50	141
EW-175	11014.51	12564.92	779.97	702.50	10	67	20	47	0.70	7.50	145
EW-176	11015.72	12314.93	778.13	700.50	10	68	20	48	0.70	7.50	145
EW-177	11029.43	12057.71	779.36	694.50	10	75	20	55	0.73	7.50	148
EW-178	11069.82	11811.42	787.50	723.00	10	55	20	35	0.63	7.50	137
EW-179	11349.42	11916.39	858.00	687.50	10	161	20	141	0.88	7.50	161
EW-180	11287.67	12131.51	844.00	686.00	10	148	20	128	0.86	7.50	160
EW-181	11305.85	12379.01	851.00	686.75	10	154	20	134	0.87	7.50	161
EW-182	11224.26	12612.05	832.78	686.50	10	136	20	116	0.85	7.50	159
EW-183	11417.12	12658.17	842.42	684.00	10	148	20	128	0.87	7.50	160
EW-184	11685.46	12672.91	837.53	688.00	10	140	20	120	0.86	7.50	159
EW-185	11974.77	12692.89	831.64	687.50	10	134	20	114	0.85	7.50	159
EW-186	12241.25	12714.25	792.68	702.50	10	80	20	60	0.75	7.50	149
EW-138R	11745.98	11217.94	920.77	693.52	10	180	20	160	0.89	7.50	162
EW-139R	11471.00	11210.00	892.39	696.78	10	180	20	160	0.89	7.50	162
EW-142R	11427.03	11263.90	840.13	691.47	10	139	20	119	0.86	7.50	159
EW-143R	11562.19	11469.53	907.44	694.23	10	180	20	160	0.89	7.50	162
EW-144R	11863.99	11468.12	897.82	691.15	10	180	20	160	0.89	7.50	162
EW-149R	11770.64	11706.02	917.00	694.08	10	180	20	160	0.89	7.50	162
EW-150R	11558.55	11722.60	908.70	696.71	10	180	20	160	0.89	7.50	162
EW-151R	11324.79	11652.43	849.69	694.41	10	145	20	125	0.86	7.50	160

* Base elevation is top of the Leachate Drainage Layer.

ATTACHMENT 4
DISCUSSION OF THE
DARCY RADIUS OF INFLUENCE
FOR LANDFILL GAS EXTRACTION SYSTEMS

Purpose: To present a design procedure for determination of gas extraction well locations and relative placement/spacing. NOTE: Values used in this discussion are examples only and are not representative of values used in the actual site design.

Method: Utilization of an individual gas extraction well's Darcy radius of influence to determine well spacing to distribute an induced vacuum uniformly throughout the waste disposal area. The concept of radial fluid flow has been used in the petroleum industry for calculating flows in porous rock reservoirs towards oil and natural gas extraction wells.

Objective: As a standard design criterion, landfill gas extraction well spacing by means of the Darcy radius of influence method should indicate a reasonable effective extraction area coverage over the waste disposal area, with minimum overlap or open spaces. Placement of gas extraction wells on side slopes should be minimized to reduce air intrusion.

Definition: The radius of influence (ROI) is the radial distance from an extraction well from which the migration direction of landfill gas will be influenced by an application of vacuum. Since gas is influenced by convection forces (pressure gradient), the radius of influence is established where the measured pressure/vacuum at extreme radius (r_1) of influence is zero.

<u>Darcy radius of influence for radial compressible fluid flow</u>

Discussion: Darcy equation, for radial fluid flow

$$v = \left(\frac{g_C \; k}{\mu} \right) \left(\frac{dP}{dr} \right) \qquad \textit{equation (1)}$$

Where:

g_c	=	acceleration of gravity constant = 32.2 (lb_M-ft/lb_F-sec^2)
v	=	apparent flow velocity in (ft/sec) units
μ	=	absolute viscosity of the flowing fluid (landfill gas) in (lb_M/ft-sec) units
K	=	absolute permeability of the porous media (refuse) in (ft^2) units
dP	=	pressure gradient in the direction of radial flow in (lb_F/ft^2) units

dr = radial distance gradient in (ft) units

Definition: Permeability is defined as a measure of a porous media's ability to transmit fluids.

Assumptions necessary to develop the basic flow equations:

(1) steady-state flow conditions exist.
(2) the pore space of the refuse is 100 percent saturated with the flowing fluid (landfill gas).
(3) the viscosity of the flowing fluid is constant.
(4) isothermal conditions in the refuse prevail.
(5) flow is laminar, horizontal, and linear since refuse grain size is relatively small and the velocity of the fluid flow is low.

Please refer to the ideal radial flow system diagram (Figure 1). With these assumptions in mind, let

$$v = \frac{q}{A}$$

Where:	v	=	the apparent velocity of the flowing fluid (gas)
	q	=	volumetric rate of fluid (gas) flow
	A	=	total cross-sectional area perpendicular to flow direction
		=	$2\pi r h_s$
	h_s	=	total extraction well length of slotted pipe

Substitute in equation (1):

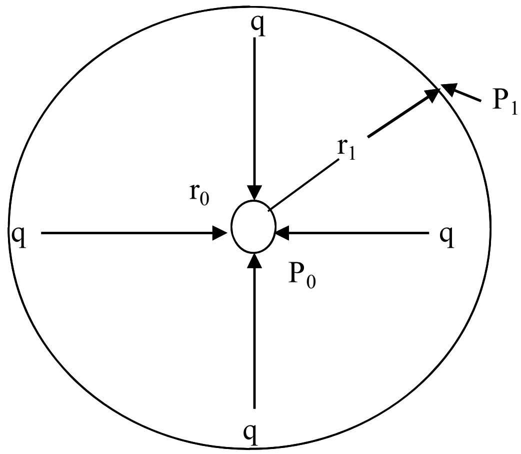
$$q \;/\; A = \left(\frac{g_C \;\; k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad \textit{equation (2)}$$

with A = $2\pi r h_s$ and rearranging

$$q = \left(\frac{2\pi \, r \, h_S \;\; g_C \;\; k}{\mu} \right) \left(\frac{dP}{dr} \right) \quad \textit{equation (3)}$$

Since landfill gas is a compressible fluid, its viscosity and flow characteristics must be corrected to standard conditions.

IDEAL RADIAL FLOW
SYSTEM DIAGRAM



TYPICAL GAS EXTRACTION
WELL DIAGRAM

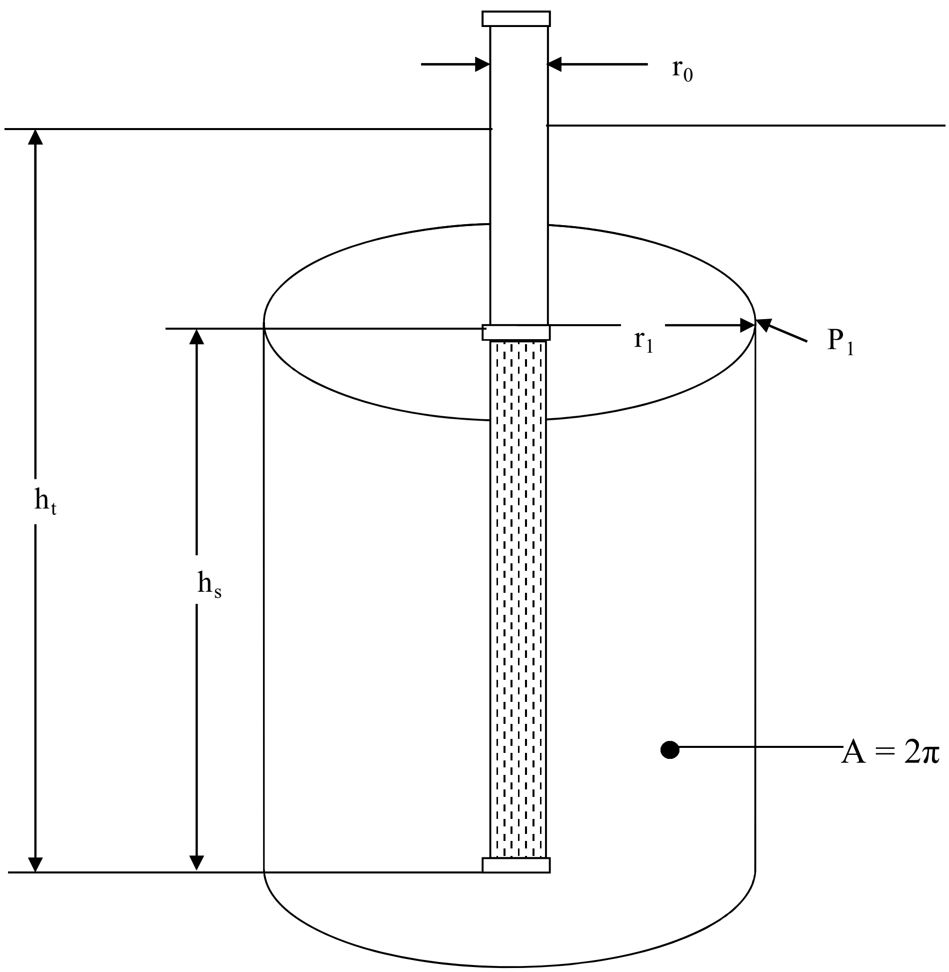


FIGURE 1: DARCY RADIUS OF INFLUENCE CONCEPTS

When a flowing fluid is compressible, then q is not constant, but is a function of pressure and temperature $f(P,T)$. An expression for the standard flow rate of a gas (q_s) is obtained from Charles' law, assuming ideal gas behavior at standard conditions:

$$\frac{P_1 \; q_1}{T_1} = \frac{P_2 \; q_2}{T_2} = constant = \frac{P_S \; q_S}{T_S} \quad \_ \quad at\ standard\ conditions$$

Substitution in equation (3):

$$\frac{P_S \; q_S}{T_S} = \frac{Pq}{T} = \left(\frac{2\pi\, r h_S \; g_C \; k}{\mu \; T} \right) \left(\frac{PdP}{dr} \right) = constant$$

Where:	T_s	=	standard temperature = 60 (°F) = 520 (°R) constant
	P_s	=	standard pressure = 14.7 (psia) = 2,116.8 (lb_F/ft^2) constant
	T	=	flowing temperature of the fluid (landfill gas)

Therefore:

$$\frac{P_S \, q_S}{T_S} = \left(\frac{2\pi \, r \, h_S \, g_C \, k}{\mu \, T} \right) \left(\frac{PdP}{dr} \right) \quad equation\ (\ 4\ )$$

let q_s = standard volumetric rate of fluid flow

$$q_S = (\ dG \ / \ dt\ )\, V\rho = (\ dG \ / \ dt\ )\, \pi\, r^2 \; h_T \; \rho$$

Where:	(dG/dt)	=	landfill gas generation rate
	V	=	volume of well influence, assuming uniform cylindrical geometry
	V	=	$\pi r^2 h_T$
	h_T	=	total extraction well length (total well depth)

This approach assumes that all conditions are uniform, and that all gas generated at radius r_1 is extracted. Actually, only a fraction of the gas generated at some distance *"r"* from the well would be extracted, and this fraction would decrease as the radius increases.

Please refer to the ideal radial flow system diagram (Figure 1).

Substitution in equation (4):

$$\frac{P_S\ (dG/dt)\ \pi r^2\ h_T\ \rho}{T_S} = \left(\frac{2\pi r h_S\ g_C\ k}{\mu T}\right)\left(\frac{PdP}{dr}\right) \qquad equation\ (5)$$

Simplification, separation of variables, and insertion of system limits in equation (5):

$$\int_{r_0}^{r_1} rdr = \frac{2 g_C\ kT_S (h_S\ /\ h_T)}{P_S (dG\ /\ dT)\ \rho\mu T} \int_{P_0}^{P_1} PdP$$

Where: r_o = radius of the extraction well pipe
r_1 = the darcy radius of influence

Which when integrated:

$$\frac{(r_1^2 - r_0^2)}{2} = \left[\frac{g_C\ \ k T_S (\ h_S / h_T\ )}{P_S (dG\ /\ dt)\rho\mu T}\ x\ \ (P_1^2 - P_0^2)\right]$$

Solving for radius of influence (r_1):

$$r_1 = \left[\frac{2 g_C\ \ k T_S (\ h_S\ \ /\ h_T\ )}{P_S (d G\ /\ d t\ )\rho\mu T}\ (\ P_1^2 - P_0^2\ ) + r_0^2\right]^{1/2} \qquad equation\ (6)$$

This is the Darcy radius of influence equation.

Since a concentric cylindrical surface at distances r_1 and r_0 are assumed, perpendicular gas flow across the surface at r_1 must be much greater than that across the surface at r_0 and since $r_0 <<< r_1$, then r_0 is negligible and:

$$r_1 = \left[\frac{2 g_C\ K T_S (\ h_S\ \ /\ h_T\ )}{P_S (d G\ \ /\ d t\ )\rho\mu T}\ (P_1^2 - P_0^2)\right]^{1/2} \qquad equation\ (7)$$

The maximum vacuum that can be applied in a gas extraction well is usually dependent on the length of solid pipe section specified. The relationship is that as the length of solid pipe section increases, the potential of air intrusion through the cover or side slopes decreases, therefore allowing more vacuum to be applied to the gas extraction well to maximize its effective radius of well influence. The average reasonable applied vacuum at the wellhead (P_o) for an active gas extraction system must be anticipated by the designer to calculate the Darcy radius of influence.

The following table is a guideline of reasonable applied vacuum values to be utilized in equation (7):

LENGTH OF SOLID PIPE (ft)	**APPLIED VACUUM (inches W.C.)**	**APPLIED VACUUM (lb_F / ft) absolute**
15	5.0	2,090.8
20	7.5	2,077.8
25	10.0	2,064.8

Note that these represent the lower range of values for reasonable applied vacuum to a well; the system's available vacuum and the actual vacuum applied will likely be much higher based on an examination of the site's gas mover equipment specifications and the typical vacuum applied to existing wells at the facility. The use of a lower vacuum range incorporates a factor of safety into the design (i.e. results in denser well spacing) since a greater applied vacuum would result in a larger ROI at a particular well, implying that the wells could be designed further apart.

The following calculation demonstrates how the Darcy radius of influence can be determined for a conceptual gas extraction well location plan.

Assumptions:

Average landfill gas composition:

percent methane (CH_4)	=	56 %		
percent carbon dioxide (CO_2)	=	43 %		
percent air (N_2/O_2)	=	1 %		
Total			=	100 %

Average flowing landfill gas temperature *(T)* = 86 (°F) = 546 (°R)

Average reasonable gas generation rate *(dG/dt)* = 0.102(ft^3/lb_M-yr)

or *(dG/dt)* = 3.234×10^{-9}(ft^3/lbM-sec)

Average reasonable applied vacuum at the wellhead *(P_o)* for an active gas extraction system with a 25-foot length of solid pipe:

P_o = 10.0 (inches of water column)
= 0.361 (psig)
= 2,064.8 (lb_F/ft^2) absolute

Conversion: 1.0 (psig) = 27.7 (inches of water column)

Average reasonable absolute permeability of refuse *(k)*.

k = 2.286×10^{-11}(ft^2)

Typical gas absolute viscosity at standard temperature conditions = 60 (°F)

Absolute Viscosity Reference Values

methane (CH_4) = 7.1×10^{-6} (lb_M/ft–sec)

carbon dioxide (CO_2) = 9.8×10^{-6} (lb_M/ft–sec)

air (N_2/O_2) = 1.2×10^{-5} (lb_M/ft–sec)

Standard landfill gas viscosity (μ) at 60 (°F):

$$\mu = (0.56)(7.1 \times 10^{-6}) + (0.43)(9.8 \times 10^{-6}) + (0.01)(1.2 \times 10^{-5})$$

$$\mu = 8.31 \times 10^{-6} \text{ } (lb_M/\text{ft–sec})$$

Determine the ratio of slotted pipe to total pipe section for typical gas extraction wells as specified by the designer.

Typical ratio value $(h_s / h_T) = 0.8$

Constants utilized in the darcy radius of well influence, equation (7):

g_c = acceleration of gravity constant = 32.2 (lbM-ft / lb_F -sec ^{2})
T_s = standard temperature = 520 (°R)
P_s = standard pressure = 2,116.8 (lb_F /ft ^{2})
ρ = density of refuse = 75.0 (lb_M /ft^3)
P_1 = vacuum at extreme radius (r_1) of influence convention pressure gradient
P_1 = 0 (inches of water column)
P_1 = 0 (psig) = 14.7 (psia) absolute
P_1 = 2,116.8 (lb_F /ft^2) absolute

Note that $P_1 = P_s = 2{,}116.8$ (lb_F /ft^2) absolute atmospheric pressure.
Substitute in equation (7) to derive the darcy radius of influence for a typical gas extraction well.

$$r_1 = \left[\frac{(2 \times 32.2)(2.286 \times 10^{-11})(520)(0.8)[(2{,}116.8)^2 - (2{,}064.8)^2]}{(2{,}116.8)(8.14 \times 10^{-9})(75)(8.31 \times 10^{-6})(560)} \right]^{1/2}$$

$$r_1 = \left[2.214 \times 10^4 (ft^2) \right]^{1/2}$$

Therefore: r_1 = 148.8 (ft) = 149 (ft) radius of well influence.

Conduct a similar evaluation on this well, but assume that the applied vacuum for the 25 foot solid pipe length is doubled to 20 inches w.c., in order to evaluate the impact of applied vacuum on the radius of influence:

P_o = 20.0 (inches of water column)
= 0.722 (psig)
= 2,012.83 (lb_F/ft^2) absolute

With all else being the same, the equation becomes:

$$r_1 = \left[\frac{(2 \times 32.2)(2.286 \times 10^{-11})(520)(0.8)[(2{,}116.8)^2 - (2{,}012.83)^2]}{(2{,}116.8)(8.14 \times 10^{-9})(75)(8.31 \times 10^{-6})(560)} \right]^{1/2}$$

r_1 = 209 (ft) radius of well influence.

APPENDIX A-3

POSITIVE PRESSURE ALLOWANCES

Allowable Gas Pressure Calculation - Closed Site			
Job:	Zion LF Horizontal Expansic	Made by:	CR
Date:	11/14/2014	Checked:	DW

REGULATION

Pursuant to 40 CFR 60.753(b)(2), positive pressure at each wellhead is allowable for those areas that use a geomembrane or synthetic cover. Further, the rule stipulates that the owner or operator develop acceptable pressure limits in the design plan.

OBJECTIVE

Calculate the maximum allowable positive pressure under the geomembrane cover such that neither the geomembrane nor the stability of the final cover are impacted.

REFERENCES

1. Infinite Slope Analysis Method
2. Thiel, R.S. (1998), "Design Methodology for a Gas Pressure Relief Layer Below a Geomembrane Landfill Cover to Improve Slope Stability", Geosynthetic International, Vol. 5, No. 6 pp. 589-617.
3. Koerner and Narejo (2005), "Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces", Geosynthetic Research Institute, GRI Report #30, June 14, 2005.

ASSUMPTIONS

Cover Configuration

	Material	**Thickness (inches)**	**Unit Weight (pcf)**	**"Weight" on Membrane (psf)**
Layer 1	Topsoil	6	134.6	67.3
Layer 2	Erosion Control Soil	30	134.6	336.5
Layer 3	Geosynthetics	0.24	60	1.2
Layer 4	Compacted Clay Cover	24	134.6	269.2
Layer 5	NA	0	0	0.0
Layer 6	NA	0	0	0.0

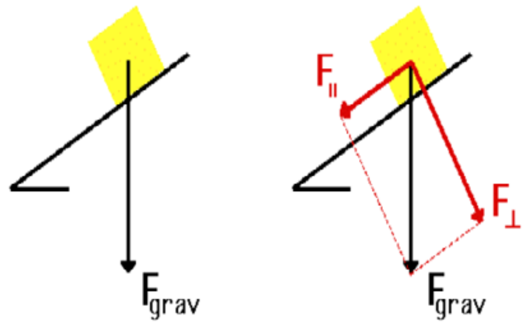
Green Cells require user input.

Slope Angle		3	:1
Slope Angle	β =	18.43	deg
Cover Thickness Perpendicular to Slope		36.24	inches
Cover Thickness Perpendicular to Slope	h =	3.02	ft
Vertical Cover Thickness	h_{ver} =	3.18	ft
"Weight" on Cover Perpendicular to Slope		405.0	psf
Equivalent Unit Weight on Cover	γ =	134.11	lbs/ft3
Geosynthetic ϕ (Clay/tx. membrane) LD	δ =	31.5	deg (from attached interface testing)
Geosynthetic Adhesion	c =	0	psf
Geosynthetic Adhesion		0.00	psi

Source of interface data: Veneer Stability Calculations

Defined Terms

$F_{||}$ = Force parallel to surface of cover
$F_{\perp}$ = Force perpendicular to cover
F_{grav} = Force of gravity due to final cover



The force of gravity can be resolved into two components. Together, these two components can replace the effect of the force of gravity.

Figure 1

CALCULATIONS:

Evaluate the following three potential impacts of positive gas pressure on the final cover system:

1) impact of positive pressure on the geomembrane seams

2) impact of positive pressure on the overlying soil material causing localized lifting and potential final cover soil movement, and

3) impact of positive pressure on the intermediate cover soil sub-base interface causing localized slope instability.

1. Impact on Geomembrane Seams:

For 40 mil (nominal) textured LDPE Geomembrane, the following are typical tensile strengths (at yield) for geomembrane seams:

Bonded seam strength (shear)	= 60 ppi (1,500 psi) = 41,520 inches water column
Peel strength (extrusion)	= 44 ppi (1,133 psi) = 30,448 inches water column
Peel strength (fusion)	= 50 ppi (1,267 psi) = 35,600 inches water column

For 40 mil (nominal) textured geomembrane, the following are the tensile strengths (at break) for the Geomembrane sheet:

Tensile strength	= 60 ppi (1,500 psi) = 41,520 inches water column

Based on the above analysis, positive gas pressures would have to exceed 30,000 psf to approach the yield strength of a geomembrane seam. Therefore, positive pressure within the landfill will have no impact on the geomembrane seams.

2. Impact on Final Cover Soils (Lifting):

Calculate the positive pressure within the landfill that would counteract the weight of the final cover soil above the geomembrane, and thus cause the soil to "float," potentially making it unstable on the landfill slope.

Note that cohesion between layers of the final cover is ignored to be conservative.

Refer to Figure 1:

Calculation for Flat Benches on Final Cover: Positive pressure must overcome F_{grav} to "float" cover soil.

$F_{grav} = h_{ver}g$ = 426.9 psf = 82.1 inches W.C

Calculation for Sideslopes of Final Cover: Positive pressure must overcome $F_{\perp}$ to "float" cover soil.

$F_{\perp} = F_{grav} \cos \beta$ = 405 psf = **77.9** inches W.C

Thus, positive gas pressures within the landfill would have to exceed 82.1 inches W.C. to cause uplift on horizontal benches

Thus, positive gas pressures within the landfill would have to exceed 77.9 inches W.C. to cause uplift on the slopes

3. Impact on Stability of Final Cover Soils

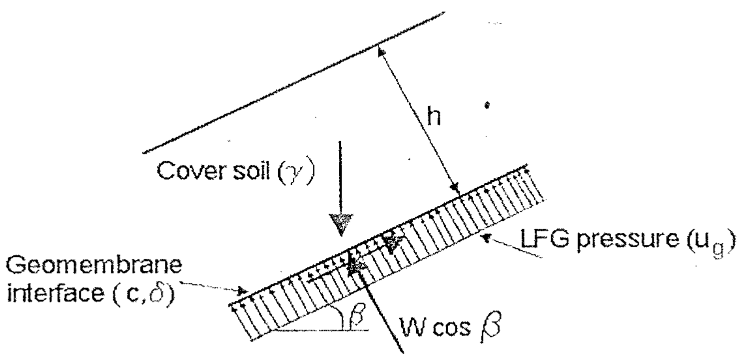
Calculate the factor of safety against sliding of the final cover assuming that the landfill is under positive pressure.

Factor of safety against sliding is defined as: $FS = F_{resist} / F_{driving}$, where

F_{resist} = Resisting forces

$F_{driving}$ = Driving forces

Using the infinite slope analysis method, which is conservative under these conditions, the resisting forces and driving forces are illustrated in the figure below. The Factor of Safety equation is shown at the bottom of the figure.



$$FS = \frac{c + (h\gamma \cos\beta - u_g) \tan\delta}{h\gamma \sin\beta}$$

Figure 2

For this analysis, the "geomembrane interface" referred to in the figure will be the interface between textured geomembrane and GCL underlying the geomembrane. This is the interface that will be subject to a reduction in normal force (and thus shear strength, or resisting force) if positive pressure builds up within the landfill.

Calculate the factor of safety of the slope using the maximum allowable gas pressure calculated in Section 2.

Maximum Allowable Gas Pressure: 77.9 inches water column

convert from inches w.c. to psf:

u_g = 405.08 psf

Resultant Factor of Safety: FS = **-0.10**

Typical minimum factor of safety using this type of analysis and for short term conditions is 1.2.

Therefore at: 77.9 inches w.c. positive pressure, slope DOES NOT MEET typical minium industry standard Factor of Safety

Calculate the positive pressure that would result in a factor of safety of 1.2 using the infinite slope analysis method.

Minimum Allowable Factor of Safety: 1.2

Maximum Allowable Gas Pressure:

$\boldsymbol{u_g}$ **= 26 inches water column**

CONCLUSIONS

Based on the calculations above, the maximum allowable positive gas pressure within the landfill is 26 inches of water column. The limiting condition is causing sliding of the cover soils on the sideslopes.

REGULATION

Pursuant to 40 CFR 60.753(b)(2), positive pressure at each wellhead is allowable for those areas that use a geomembrane or synthetic cover. Further, the rule stipulates that the owner or operator develop acceptable pressure limits in the design plan.

OBJECTIVE

Calculate the maximum allowable positive pressure under the geomembrane cover such that neither the geomembrane nor the stability of the final cover are impacted.

REFERENCES

1. Infinite Slope Analysis Method
2. Thiel, R.S. (1998), "Design Methodology for a Gas Pressure Relief Layer Below a Geomembrane Landfill Cover to Improve Slope Stability", Geosynthetic International, Vol. 5, No. 6 pp. 589-617.
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	Material	Thickness (inches)	Unit Weight (pcf)	"Weight" on Membrane (psf)
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Layer 3	Geosynthetics	0.24	60	1.2
Layer 4	Compacted Clay Cover	24	134.6	269.2
Layer 5	NA	0	0	0.0
Layer 6	NA	0	0	0.0

Green Cells require user input.

Slope Angle		4	:1
Slope Angle	β =	14.04	deg
Cover Thickness Perpendicular to Slope		36.24	inches
Cover Thickness Perpendicular to Slope	h =	3.02	ft
Vertical Cover Thickness	h_{ver} =	3.11	ft
"Weight" on Cover Perpendicular to Slope		405.0	psf
Equivalent Unit Weight on Cover	γ =	134.11	lbs/ft3
Geosynthetic ϕ (Clay/tx. membrane) LD	δ =	31.5	deg (from attached interface testing)
Geosynthetic Adhesion	c =	0	psf
Geosynthetic Adhesion		0.00	psi

Source of interface data: Veneer Stability Calculations

Defined Terms

$F_{||}$ = Force parallel to surface of cover
$F_{\perp}$ = Force perpendicular to cover
F_{grav} = Force of gravity due to final cover

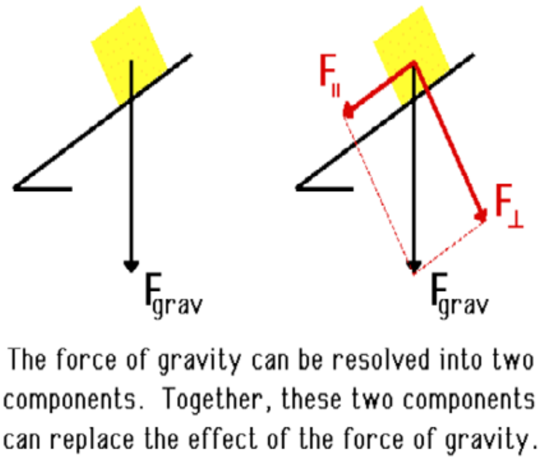

Figure 1

CALCULATIONS:

Evaluate the following three potential impacts of positive gas pressure on the final cover system:

1) impact of positive pressure on the geomembrane seams

2) impact of positive pressure on the overlying soil material causing localized lifting and potential final cover soil movement, and

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For 40 mil (nominal) textured LDPE Geomembrane, the following are typical tensile strengths (at yield) for geomembrane seams:

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Peel strength (fusion)	= 50 ppi (1,267 psi) = 35,600 inches water column

For 40 mil (nominal) textured geomembrane, the following are the tensile strengths (at break) for the Geomembrane sheet:

Tensile strength	= 60 ppi (1,500 psi) = 41,520 inches water column

Based on the above analysis, positive gas pressures would have to exceed 30,000 psf to approach the yield strength of a geomembrane seam. Therefore, positive pressure within the landfill will have no impact on the geomembrane seams.

2. Impact on Final Cover Soils (Lifting):

Calculate the positive pressure within the landfill that would counteract the weight of the final cover soil above the geomembrane, and thus cause the soil to "float," potentially making it unstable on the landfill slope.

Note that cohesion between layers of the final cover is ignored to be conservative.

Refer to Figure 1:

Calculation for Flat Benches on Final Cover: Positive pressure must overcome F_{grav} to "float" cover soil.

$F_{grav} = h_{ver}g$ = 417.5 psf = 80.3 inches W.C

Calculation for Sideslopes of Final Cover: Positive pressure must overcome $F_{\perp}$ to "float" cover soil.

$F_{\perp} = F_{grav} \cos \beta$ = 405 psf = **77.9** inches W.C

Thus, positive gas pressures within the landfill would have to exceed 80.3 inches W.C. to cause uplift on horizontal benches

Thus, positive gas pressures within the landfill would have to exceed 77.9 inches W.C. to cause uplift on the slopes

3. Impact on Stability of Final Cover Soils

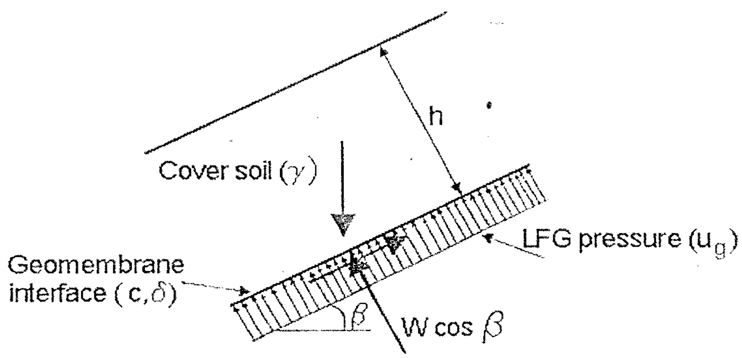
Calculate the factor of safety against sliding of the final cover assuming that the landfill is under positive pressure.

Factor of safety against sliding is defined as: $FS = F_{resist} / F_{driving}$, where

F_{resist} = Resisting forces

$F_{driving}$ = Driving forces

Using the infinite slope analysis method, which is conservative under these conditions, the resisting forces and driving forces are illustrated in the figure below. The Factor of Safety equation is shown at the bottom of the figure.



$$FS = \frac{c + (h\gamma \cos\beta - u_g)\tan\delta}{h\gamma \sin\beta}$$

Figure 2

For this analysis, the "geomembrane interface" referred to in the figure will be the interface between textured geomembrane and GCL underlying the geomembrane. This is the interface that will be subject to a reduction in normal force (and thus shear strength, or resisting force) if positive pressure builds up within the landfill.

Calculate the factor of safety of the slope using the maximum allowable gas pressure calculated in Section 2.

Maximum Allowable Gas Pressure: 77.9 inches water column

convert from inches w.c. to psf:

u_g = 405.08 psf

Resultant Factor of Safety: *FS* = **-0.08**

Typical minimum factor of safety using this type of analysis and for short term conditions is 1.2.

Therefore at: 77.9 inches w.c. positive pressure, slope DOES NOT MEET typical minium industry standard Factor of Safety

Calculate the positive pressure that would result in a factor of safety of 1.2 using the infinite slope analysis method.

Minimum Allowable Factor of Safety: 1.2

Maximum Allowable Gas Pressure:

u_g = 39 inches water column

CONCLUSIONS

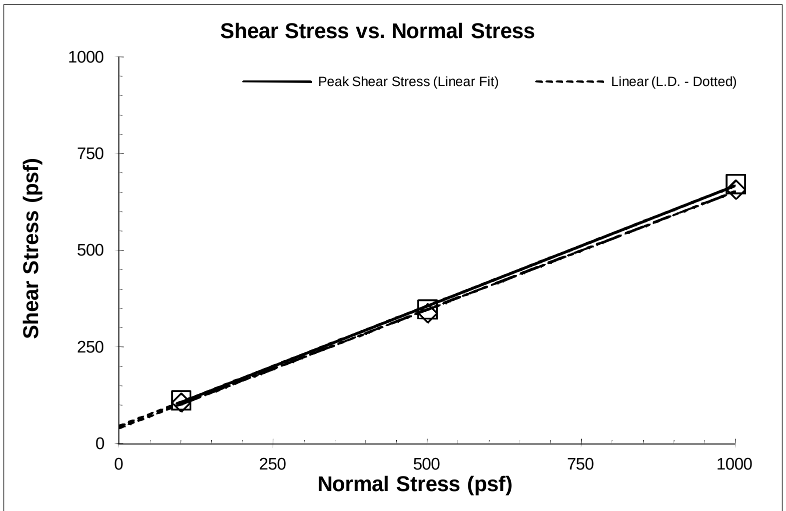
Based on the calculations above, the maximum allowable positive gas pressure within the landfill is 39 inches of water column. The limiting condition is causing sliding of the cover soils on the sideslopes.

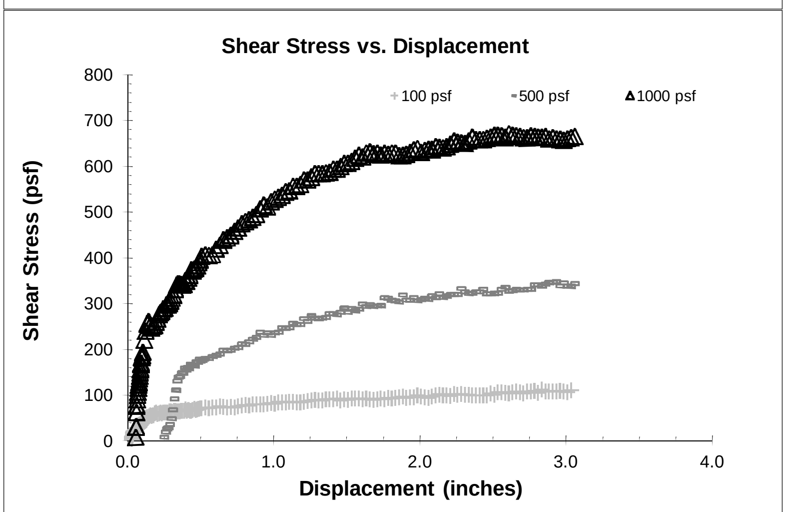
TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Interface Friction Test Report

Client:	**Veolia Environmental Services**	TRI Log#: E2365-93-04	John M. Allen, P.E., 10/08/2012
Project:	**Zion Landfill, 2012 Cap**	Test Method: ASTM D 5321	Quality Review/Date
Test Date:	10/05/12-10/08/12		

Tested Interface: Clay Soil vs. GSE 40 mil LLDPE Textured Geomembrane





Test Results

	Peak	Large Displacement (@ 3.0 in.)
Friction Angle (degrees):	**31.9**	**31.5**
Y-intercept or Adhesion (psf):	**46**	**41**

Shearing occurred at the interface.

Test Conditions

Upper Box &	Clay Soil remolded to 131 pcf ato 11.5% moisture content
Lower Box	GSE 40 mil LLDPE textured geomembrane
Box Dimensions:	12"x12"x4"
Interface Conditioning:	Interface soaked and loading applied for a minimum of 16 hours prior to shear.
Test Condition:	Wet
Shearing Rate:	0.04 inches/minute

Test Data

Specimen No.	1	2	3
Bearing Slide Resistance (lbs)	9	13	18
Normal Stress (psf)	100	500	1000
Corrected Peak Shear Stress (psf)	113	349	672
Corrected Large Displacement Shear Stress (psf)	108	338	658
Peak Secant Angle (degrees)	48.4	34.9	33.9
Large Displacement Secant Angle (degrees)	47.2	34.1	33.3
Asperity (mils)	27.8	29.0	28.0

9063 Bee Caves Road □ Austin, TX 78733-6201 □ (512) 263-2101 □ (512) 263-2558 □ 1-800-880-TEST

Appendix B

APPENDIX B

HEAD LOSS ANALYSIS

INTRODUCTION

A crucial step in designing a gas collection system is to lay out a routing for the header line and laterals to connect each of the gas wells into the system, and convey the collected gas to a central location for destruction. After the design engineer has routed the most efficient header system for collecting gas from the extraction wells, the header pipe must be sized appropriately to convey the maximum expected gas flow [40 CFR §60.752(b)(2)(ii)(A)(1)]. Typical design criteria and header construction methods are generally discussed in the following subsections.

The ADS - Zion Landfill has an existing gas collection system over a portion of the waste. The following provides a narrative describing the results of a KYGas® analysis of the landfill gas collection and control system (GCCS) installed at the landfill. The purpose of conducting this analysis was to evaluate the following:

- Pressure distribution profile for the existing piping system;
- Verify that the existing and future piping system is adequately sized and that the sizing is consistent with current industry practices; and
- Confirm the existing landfill gas blower inlet vacuums are adequate for GCCS operation.

The KYGas® model was developed by the University of Kentucky for performing water and gas distribution flow analyses. The program uses a 2-dimensional model depicting the geometry of the piping system. Once the 2-dimension layout of the system has been entered into the model, the user enters the physical properties of the gas, plus other site-specific parameters for the size and type of pipe, gas flow requirements, and operating pressure conditions to calculate the system gas velocities and pressure distribution.

KYGas® utilizes the Ideal Gas Law for pressure-temperature-density relationships and the Darcy-Weisbach equation for head losses related to uncompressible flow. The program operates under the assumption that all flow in the piping system is steady, one-dimensional, isothermal flow for an ideal gas.

MODEL INPUT DATA

The GCCS layout and pipe sizes used in the model were based on as-built information for the headers and laterals in the existing gas collection system, and the proposed gas system design for the future horizontal expansion provided in Appendix C. High density polyethylene (HDPE) piping having a standard dimension ratio (SDR) rating of 17 was assumed for the inside pipe diameters. Other parameters required for the model include:

- Pipe length
- Roughness within the pipe
- Minor loss coefficient

- LFG operating temperature (assumed to be 100 ºF)
- LFG flow rate into the system at each well or node
- Ratio of specific heats (1.303)
- Specific gravity of the landfill gas (1.036)
- Absolute viscosity of the landfill gas (2.82 x 10^{-7} lb*sec/ft^2)

The landfill gas (LFG) flow rates used in the model were derived from projected gas flow rates from the active and the closed portions of the site in the year 2024 (peak flow condition). For the closed Phase 1a, Phase 1b/Old Site 2 areas, the gas flow rate in the year 2024 totals 704 scfm. This flow rate was divided among the 63 wells currently existing in these closed areas to estimate an average flow per well of 11.17 cfm. This is reasonable flow rate for wells in closed areas where the waste age is approaching 35 years.

In the active and future horizontal expansion areas, the combined modeled flow rate in the year 2024 is 7,615 scfm. This flow rate was divided proportionately between the 56 interior and 25 perimeter wells by assuming that the shallow perimeter wells have half the flow rate of the deeper interior wells. A flow rate of 111.17 cfm was assumed for the interior wells, and a flow rate of 55.58 cfm was used in the model for the perimeter wells.

The facility's total LFG generation rate was calculated to be 8,319 standard cubic feet per minute (scfm) in the year 2024. This flow condition was selected as the peak flow condition for the KYGas® model.

The KYGas® model requires the user to specify an operating pressure for each vacuum source used in the analysis. Based on information provided by the facility, the blower equipment for the enclosed flare and landfill gas to energy plant consists of two 150 HP HSI blowers each designed for 100 inches water column gauge ("w.c.) of vacuum and 3,000 SCFM of flow. The open flare has a 75 HP HSI blower designed for 58" w.c. of vacuum and 3,000 SCFM of flow. A maximum vacuum of 58" w.c. was conservatively used during the KYGas® analysis for all of the blowers at the site.

A second run was conducted (but is not included), which assumed all gas flow is directed to the enclosed flare and LFGTE plant as an alternate operating scenario. Additionally, under this operating scenario, the available vacuum from the gas mover equipment for the enclosed flare and LFGTE plant is 100" w.c. The minimum pipe sizing selected for future header in the first model run met all design criteria for the second gas system operating scenario.

The user can start the evaluation of the system once all of the required information is input into the program. This evaluation is an iterative process. Multiple model runs are conducted by adjusting the pipe diameter, until the velocities in the system piping and the vacuum pressure remaining at the furthest node meet design requirements.

The design criteria utilized for the header system is:

- Maximum Concurrent velocity: 40 feet/second

- Maximum Countercurrent velocity: 20 feet/second
- Maximum pressure drop: 1 inch per 100 feet of pipe
- Minimum vacuum at any node/well: 25 inches of water column

DESCRIPTION OF KYGAS® MODEL RESULTS

A copy of the KYGas® model print out for the ADS - Zion Landfill is provided as Attachment 5. Also included are six model-generated layouts of the GCCS. Figures 1a (active portion of the site) and 1b (closed portion of the site) identify the pipe segment and pipe node names used by the model for the closed and active areas, respectively. These names can be used to reference the information on the model print-out. Figures 2a and figure 2b show the pipe sizes used in each area of the site, and Figures 3a and 3b show the available vacuum at each well, and the calculated flow rate through each pipe segment.

A summary of the simulation is provided in Attachment 5, including gas parameters and units of measure. The geometry and operating criteria used in the model is identified, including pipe names, nodes that connect to each pipe segment, pipe lengths and diameters, and pipe roughness.

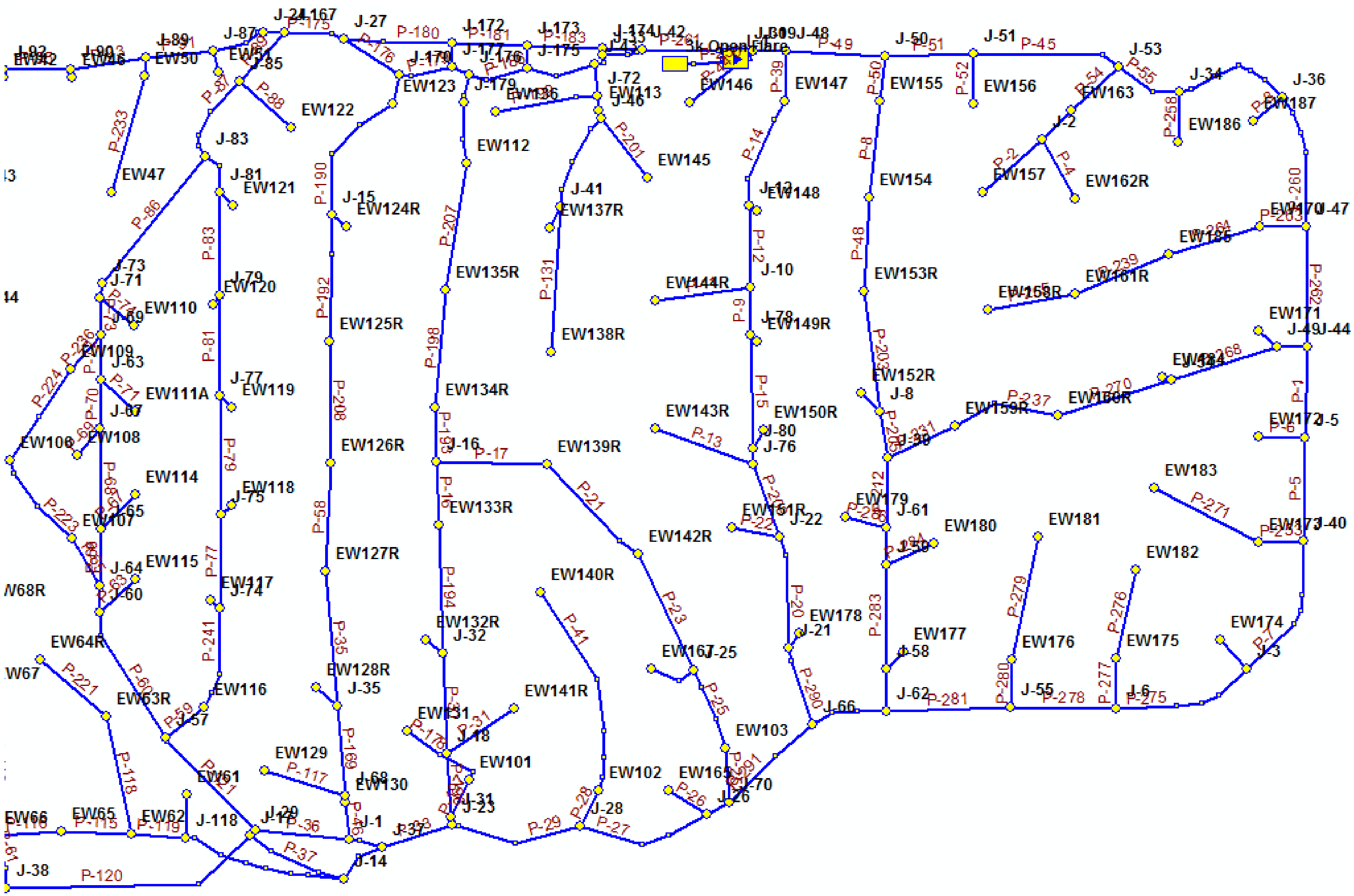
The next set of pages summarizes the junction "nodes" and their "demand", or the unit flow rate for the quantity of LFG entering the system at that node location. Because the GCCS operates under a negative pressure, the operating flow rates and pressures are entered as negative numbers. Column 3 indicates the LFG extraction flow rate that is introduced to the piping system at that junction location.

The modeling results for each pipe segment are then provided. This includes the calculated LFG flow rate through each pipe segment. A negative number indicates the direction of LFG flow is reversed from the orientation indicated by the pipe nodes. Also shown is the calculated friction loss along the length of pipe segment expressed in inches of water column, the calculated velocity of the LFG flowing through the pipe segment, the density of LFG used in the calculations, and a variable calculated by the model for each pipe segment based on flow rate.

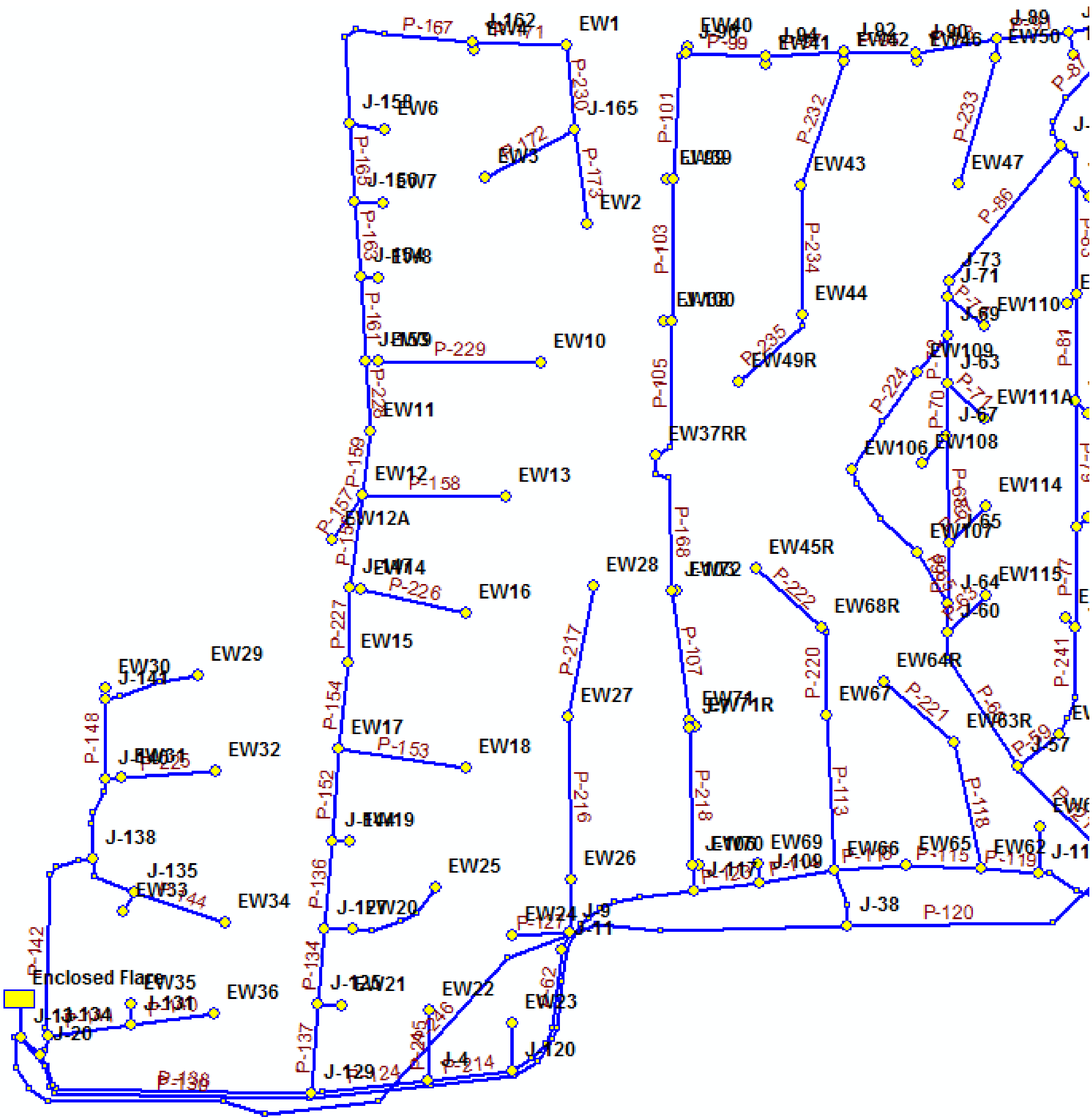
SUMMARY OF ZION LANDFILL KYGAS® RESULTS

The KYGas® results indicate that all values are well within the specified design criteria for the proposed piping at ADS - Zion Landfill, and the minimum pipe sizes selected should be sufficient to convey the expected gas flow rates from the expansion.

ZION LANDFILL
FIGURE 1a: PIPE SEGMENT AND PIPE NODE NAMES

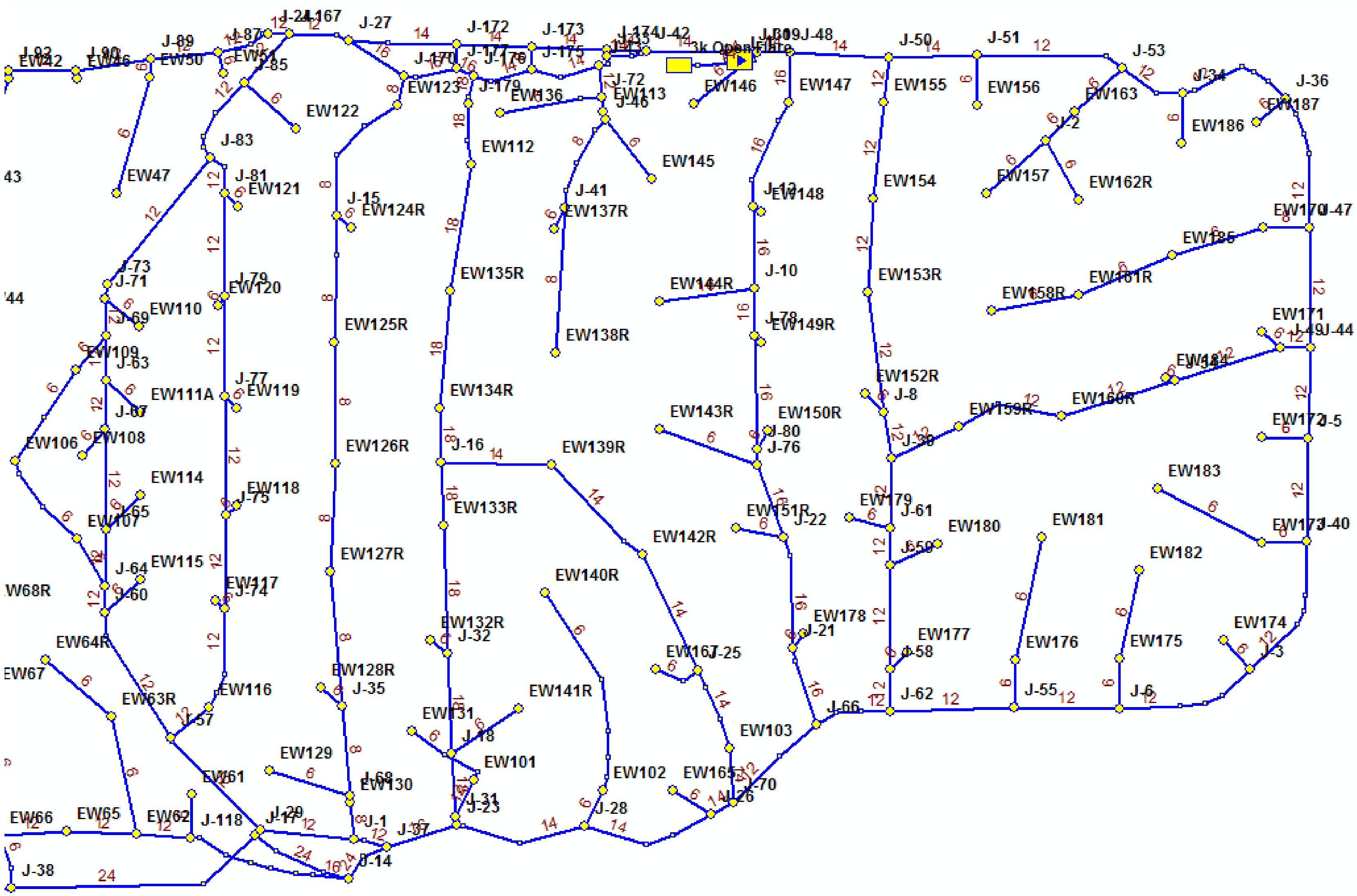


ZION LANDFILL
FIGURE 1b: PIPE SEGMENT AND PIPE NODE NAMES

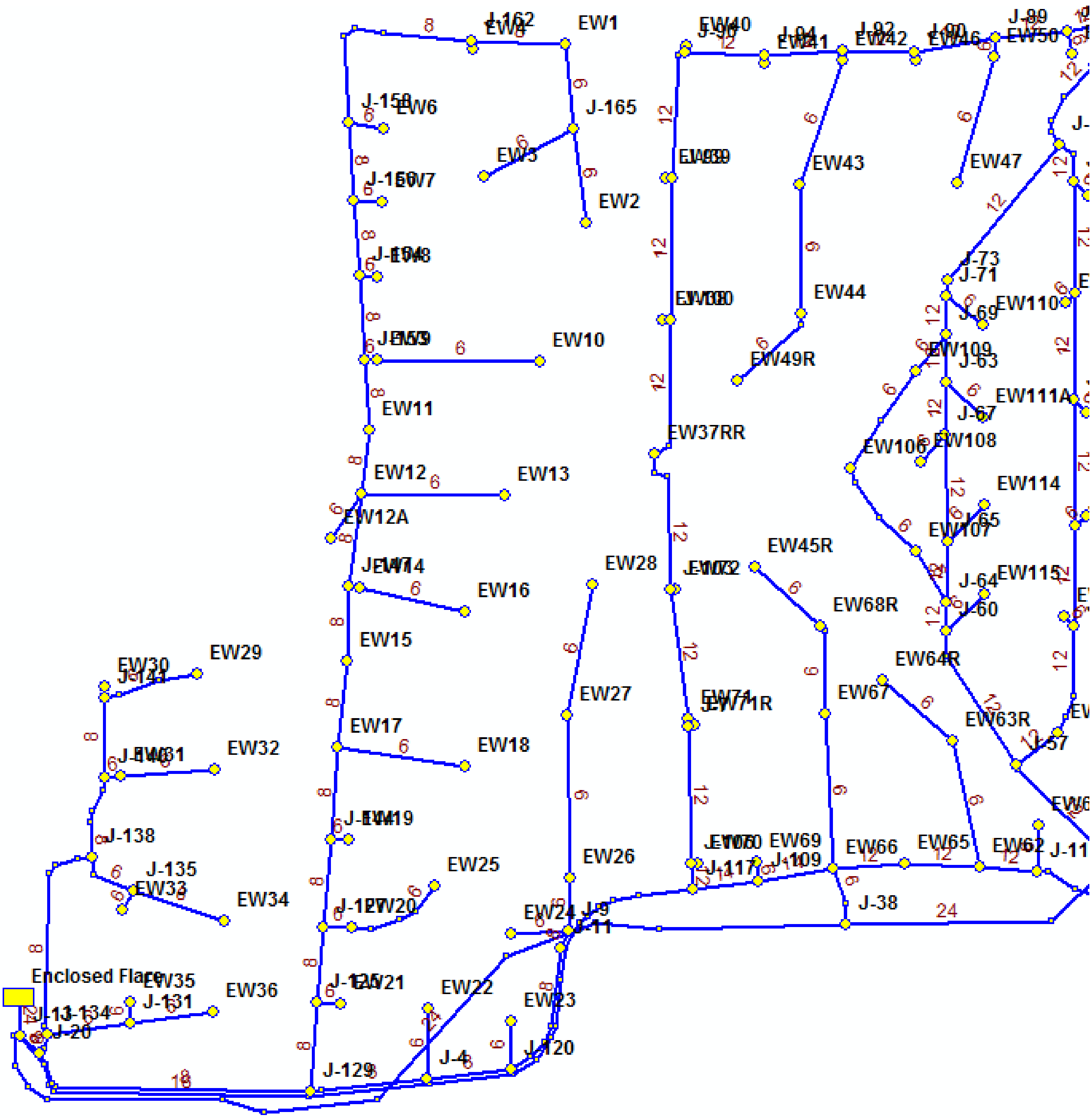


ZION LANDFILL

FIGURE 2a: MINIMUM PIPE SIZES.

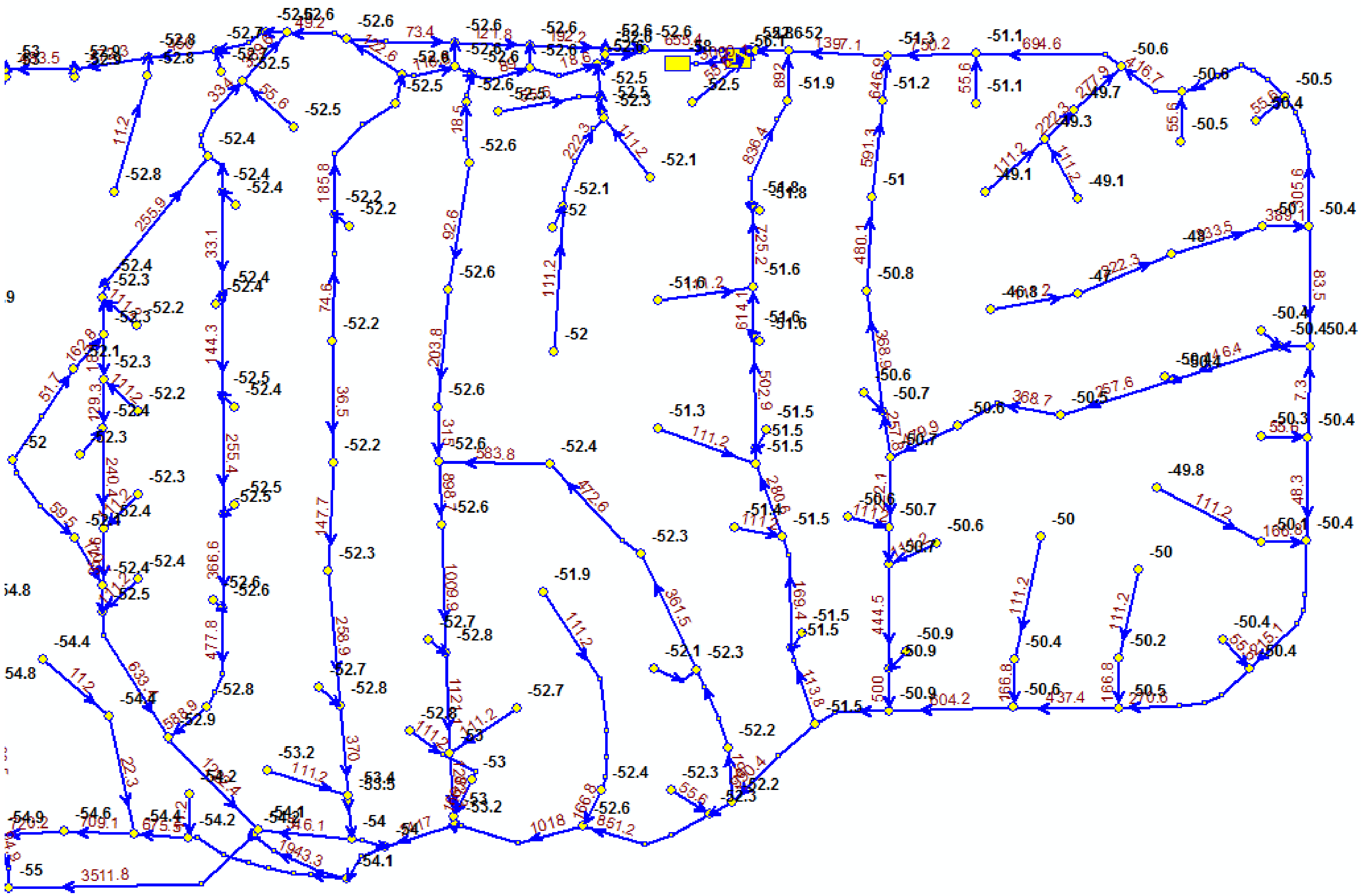


ZION LANDFILL
FIGURE 2b: MINIMUM PIPE SIZES



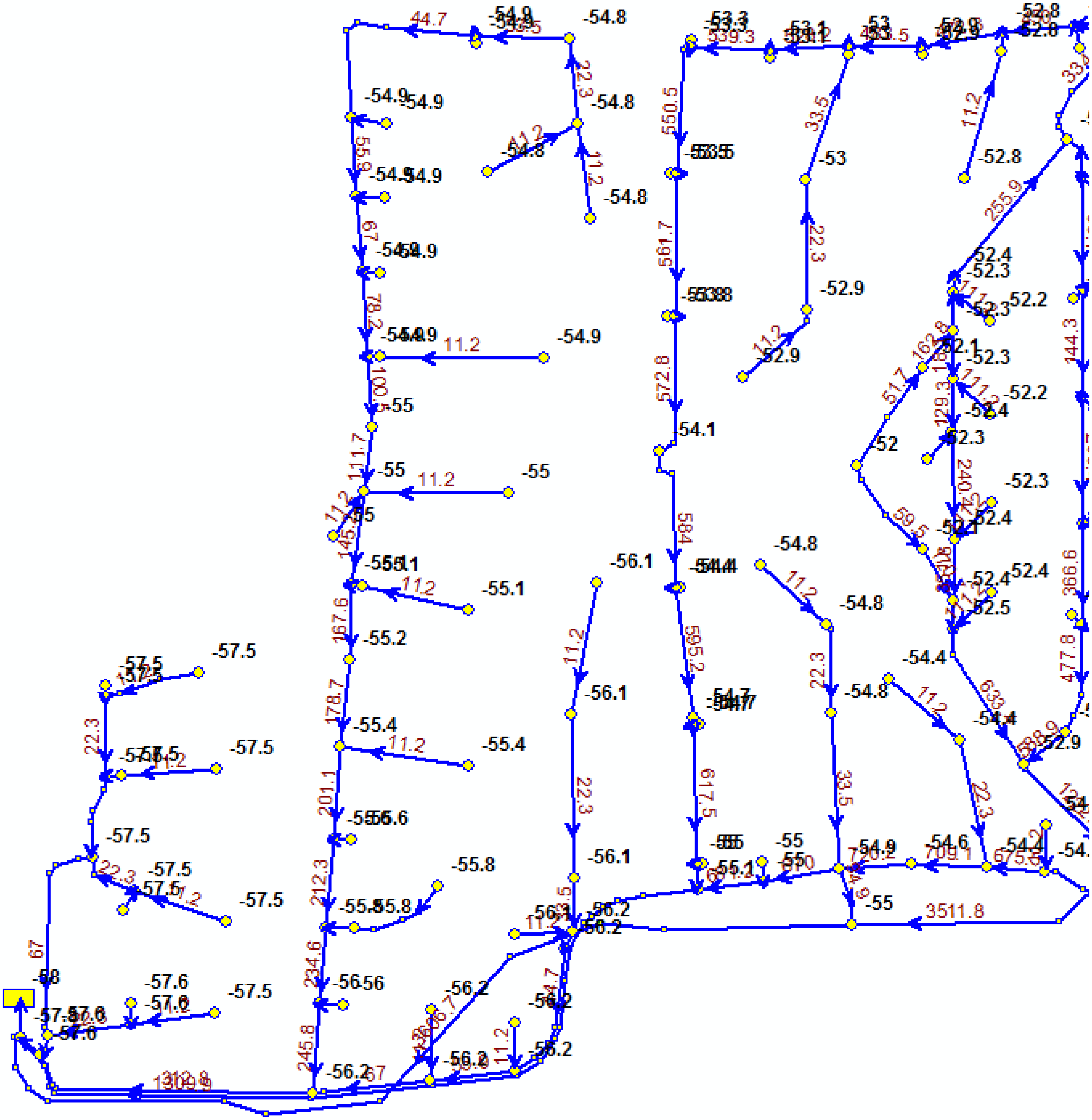
ZION LANDFILL

FIGURE 3a: AVAILABLE VACUUM AND PIPE SEGMENT FLOW



ZION LANDFILL

FIGURE 3b: AVAILABLE VACUUM AND PIPE SEGMENT FLOW



ATTACHMENT 5

KYGas® MODEL RESULTS

* * * * * * * * * * * * * K Y G A S * * * * * * * * * * * * *
*   *
* Gas Network Analysis Software   *
*   *
* CopyRighted by KYPIPE LLC (www.kypipe.com)   *
* Version: 6.025 10/21/2013   *
* Serial #: 8-5537277   *
* Interface: Classic   *
* Licensed for Pipe2006   *
*   *
* *

INPUT DATA FILE NAME FOR THIS SIMULATION = c:\eil\EILPRO~1\ads\zion\AIRQUA~1\K
YPIPE~1\2014KY~1\2014KY~1\ZID760~1.KYP\zion2014.DAT
OUTPUT DATA FILE NAME FOR THIS SIMULATION = c:\eil\EILPRO~1\ads\zion\AIRQUA~1\K
YPIPE~1\2014KY~1\2014KY~1\ZID760~1.KYP\zion2014.OT2

DATE FOR THIS COMPUTER RUN   : 12-02-2014
START TIME FOR THIS COMPUTER RUN : 14: 8:40:98

SUMMARY OF DISTRIBUTION SYSTEM CHARACTERISTICS:

NUMBER OF PIPES   =   286
NUMBER OF JUNCTION NODES =   268

UNITS SPECIFIED   = ENGLISH

A CONSTANT DENSITY FLUID IS SPECIFIED - DENSITY =   .08POUNDS/CUBIC FOOT
ABSOLUTE VISCOSITY   =   .230E-06 POUND SECONDS/SQUARE FOOT

USER SPEC. FLOW UNITS (USFU)   = SCF / MIN.
USER SPEC. PRESSURE UNITS(USPU) = INCHES OF WATER (GAUGE)

------- SUMMARY OF PIPE NETWORK GEOMETRIC AND OPERATING DATA -------

----
PIPE   NODE   NODE LENGTH DIAM. ROUGHNESS SUM-M PUMP ELEVATION
NAME   #1   #2   (FT.) (IN.) (MILLIFEET) FACT. ID   CHANGE

P-1	J-44	J-5	214.0	11.3	.400	.0	0	.0
P-10	EW148	J-12	23.0	14.0	.400	.0	0	.0
P-100	J-96	EW40	15.0	5.8	.400	.0	0	.0
P-101	J-96	J-99	286.0	11.3	.400	.0	0	.0
P-102	J-99	EW39	17.0	5.8	.400	.0	0	.0
P-103	J-99	J-100	317.0	11.3	.400	.0	0	.0
P-104	J-100	EW38	18.0	5.8	.400	.0	0	.0
P-105	J-100	EW37RR	314.0	11.3	.400	.0	0	.0
P-106	J-103	EW72	13.0	5.8	.400	.0	0	.0
P-107	J-103	EW71	290.0	11.3	.400	.0	0	.0
P-108	EW123	J-170	70.0	7.6	.400	.0	0	.0
P-109	EW130	J-68	18.0	7.6	.400	.0	0	.0
P-11	J-10	EW144R	227.0	14.0	.400	.0	0	.0
P-110	J-106	EW70	17.0	5.8	.400	.0	0	.0
P-111	J-106	J-117	57.0	11.3	.400	.0	0	.0
P-112	J-109	EW69	42.0	5.8	.400	.0	0	.0
P-113	EW66	EW67	344.0	5.8	.400	.0	0	.0
P-114	J-109	EW66	167.0	12.5	.400	.0	0	.0
P-115	EW62	EW65	166.0	11.3	.400	.0	0	.0
P-116	EW65	EW66	159.0	11.3	.400	.0	0	.0
P-117	J-68	EW129	199.0	5.8	.400	.0	0	.0
P-118	EW62	EW63R	286.0	5.8	.400	.0	0	.0
P-119	EW62	J-118	128.0	11.3	.400	.0	0	.0
P-12	J-12	J-10	195.0	14.0	.400	.0	0	.0
P-120	J-38	J-17	622.0	21.0	.400	.0	0	.0
P-121	J-57	J-29	306.0	11.3	.400	.0	0	.0
P-122	J-118	EW61	103.0	5.8	.400	.0	0	.0
P-123	J-117	J-109	149.0	12.5	.400	.0	0	.0
P-124	J-4	J-129	260.0	7.6	.400	.0	0	.0
P-125	J-13	Enclosed	85.0	21.0	.400	.0	0	.0
P-126	J-11	J-9	42.0	7.6	.400	.0	0	.0
P-127	J-9	EW24	124.0	5.8	.400	.0	0	.0
P-128	J-9	EW26	118.0	5.8	.400	.0	0	.0
P-129	J-120	EW23	106.0	5.8	.400	.0	0	.0
P-13	J-76	EW143R	247.0	5.8	.400	.0	0	.0
P-130	J-117	J-13	1822.0	14.0	.400	.0	0	.0
P-131	J-41	EW138R	344.0	7.6	.400	.0	0	.0
P-132	J-17	J-29	19.0	11.3	.400	.0	0	.0
P-133	J-125	EW21	52.0	5.8	.400	.0	0	.0
P-134	J-125	J-127	167.0	7.6	.400	.0	0	.0
P-135	J-127	EW20	66.0	5.8	.400	.0	0	.0
P-136	J-127	J-144	195.0	7.6	.400	.0	0	.0
P-137	J-129	J-125	200.0	7.6	.400	.0	0	.0
P-138	J-129	J-20	651.0	7.6	.400	.0	0	.0
P-139	J-131	EW35	45.0	5.8	.400	.0	0	.0
P-14	J-12	EW147	268.0	14.0	.400	.0	0	.0
P-140	J-131	EW36	186.0	5.8	.400	.0	0	.0

P-141	J-134	J-131	186.0	5.8	.400	.0	0	.0
P-142	J-134	J-138	464.0	7.6	.400	.0	0	.0
P-143	J-135	EW33	49.0	5.8	.400	.0	0	.0
P-144	J-135	EW34	212.0	5.8	.400	.0	0	.0
P-145	J-138	J-135	134.0	5.8	.400	.0	0	.0
P-146	J-138	J-140	185.0	7.6	.400	.0	0	.0
P-147	J-140	EW31	35.0	5.8	.400	.0	0	.0
P-148	J-140	J-141	178.0	7.6	.400	.0	0	.0
P-149	J-141	EW30	24.0	5.8	.400	.0	0	.0
P-15	J-80	J-78	270.0	14.0	.400	.0	0	.0
P-150	J-141	EW29	212.0	5.8	.400	.0	0	.0
P-151	J-144	EW19	37.0	5.8	.400	.0	0	.0
P-152	J-144	EW17	205.0	7.6	.400	.0	0	.0
P-153	EW17	EW18	285.0	5.8	.400	.0	0	.0
P-154	EW17	EW15	194.0	7.6	.400	.0	0	.0
P-155	J-147	EW14	26.0	5.8	.400	.0	0	.0
P-156	J-147	EW12	209.0	7.6	.400	.0	0	.0
P-157	EW12	EW12A	121.0	5.8	.400	.0	0	.0
P-158	EW12	EW13	319.0	5.8	.400	.0	0	.0
P-159	EW12	EW11	143.0	7.6	.400	.0	0	.0
P-16	J-16	EW133R	151.0	15.8	.400	.0	0	.0
P-160	J-153	EW9	27.0	5.8	.400	.0	0	.0
P-161	J-153	J-154	186.0	7.6	.400	.0	0	.0
P-162	J-154	EW8	40.0	5.8	.400	.0	0	.0
P-163	J-154	J-156	168.0	7.6	.400	.0	0	.0
P-164	J-156	EW7	63.0	5.8	.400	.0	0	.0
P-165	J-156	J-158	171.0	7.6	.400	.0	0	.0
P-166	J-158	EW6	79.0	5.8	.400	.0	0	.0
P-167	J-158	J-162	481.0	7.6	.400	.0	0	.0
P-168	EW37RR	J-103	322.0	11.3	.400	.0	0	.0
P-169	J-35	J-68	212.0	7.6	.400	.0	0	.0
P-17	EW139R	J-16	262.0	12.5	.400	.0	0	.0
P-170	J-162	EW4	19.0	5.8	.400	.0	0	.0
P-171	J-162	EW1	211.0	7.6	.400	.0	0	.0
P-172	J-165	EW3	224.0	5.8	.400	.0	0	.0
P-173	J-165	EW2	212.0	5.8	.400	.0	0	.0
P-174	J-167	J-24	49.0	11.3	.400	.0	0	.0
P-175	J-167	J-27	143.0	11.3	.400	.0	0	.0
P-176	J-27	J-170	157.0	14.0	.400	.0	0	.0
P-177	J-30	J-19	23.0	12.5	.400	.0	0	.0
P-178	EW101	EW131	207.0	5.8	.400	.0	0	.0
P-179	J-170	J-177	125.0	14.0	.400	.0	0	.0
P-18	J-80	EW150R	50.0	5.8	.400	.0	0	.0
P-180	J-172	J-27	257.0	12.5	.400	.0	0	.0
P-181	J-172	J-173	180.0	12.5	.400	.0	0	.0
P-182	J-174	J-42	93.0	12.5	.400	.0	0	.0
P-183	J-173	J-174	178.0	12.5	.400	.0	0	.0

P-184	J-175	J-43	164.0	12.5	.400	.0	0	.0
P-185	J-173	J-175	51.0	7.6	.400	.0	0	.0
P-186	J-176	J-175	143.0	12.5	.400	.0	0	.0
P-187	J-177	J-172	56.0	7.6	.400	.0	0	.0
P-188	J-176	J-177	47.0	14.0	.400	.0	0	.0
P-189	EW113	J-72	32.0	11.3	.400	.0	0	.0
P-19	J-21	EW178	41.0	5.8	.400	.0	0	.0
P-190	J-15	EW123	332.0	7.6	.400	.0	0	.0
P-191	J-179	J-176	67.0	15.8	.400	.0	0	.0
P-192	J-15	EW125R	300.0	7.6	.400	.0	0	.0
P-193	EW134R	J-16	128.0	15.8	.400	.0	0	.0
P-194	J-32	EW133R	304.0	15.8	.400	.0	0	.0
P-195	EW132R	J-32	52.0	5.8	.400	.0	0	.0
P-196	J-18	J-31	149.0	15.8	.400	.0	0	.0
P-197	J-31	EW101	96.0	11.3	.400	.0	0	.0
P-198	EW135R	EW134R	281.0	15.8	.400	.0	0	.0
P-199	EW136	J-72	244.0	5.8	.400	.0	0	.0
P-2	J-2	EW157	189.0	5.8	.400	.0	0	.0
P-20	J-21	J-22	266.0	14.0	.400	.0	0	.0
P-200	J-72	J-43	77.0	11.3	.400	.0	0	.0
P-201	J-46	EW145	178.0	5.8	.400	.0	0	.0
P-202	J-46	J-41	236.0	7.6	.400	.0	0	.0
P-203	EW153R	J-8	287.0	11.3	.400	.0	0	.0
P-204	J-8	EW152R	62.0	5.8	.400	.0	0	.0
P-205	J-8	J-39	110.0	11.3	.400	.0	0	.0
P-206	J-3	EW174	95.0	5.8	.400	.0	0	.0
P-207	EW135R	EW112	304.0	15.8	.400	.0	0	.0
P-208	EW125R	EW126R	289.0	7.6	.400	.0	0	.0
P-209	J-22	J-76	184.0	14.0	.400	.0	0	.0
P-21	EW139R	EW142R	304.0	12.5	.400	.0	0	.0
P-210	J-76	J-80	36.0	14.0	.400	.0	0	.0
P-211	EW149R	J-78	22.0	5.8	.400	.0	0	.0
P-212	J-39	J-61	165.0	11.3	.400	.0	0	.0
P-213	EW20	EW25	217.0	5.8	.400	.0	0	.0
P-214	J-4	J-120	191.0	7.6	.400	.0	0	.0
P-215	J-4	EW22	156.0	5.8	.400	.0	0	.0
P-216	EW26	EW27	359.0	5.8	.400	.0	0	.0
P-217	EW27	EW28	296.0	5.8	.400	.0	0	.0
P-218	J-7	J-106	304.0	11.3	.400	.0	0	.0
P-219	J-7	EW71R	15.0	5.8	.400	.0	0	.0
P-22	J-22	EW151R	115.0	5.8	.400	.0	0	.0
P-220	EW67	EW68R	203.0	5.8	.400	.0	0	.0
P-221	EW63R	EW64R	206.0	5.8	.400	.0	0	.0
P-222	EW68R	EW45R	195.0	5.8	.400	.0	0	.0
P-223	EW107	EW106	238.0	5.8	.400	.0	0	.0
P-224	EW106	EW109	258.0	5.8	.400	.0	0	.0
P-225	EW31	EW32	209.0	5.8	.400	.0	0	.0

P-226	EW14	EW16	239.0	5.8	.400	.0	0	.0
P-227	EW15	J-147	164.0	7.6	.400	.0	0	.0
P-228	EW11	J-153	156.0	7.6	.400	.0	0	.0
P-229	EW9	EW10	361.0	5.8	.400	.0	0	.0
P-23	J-25	EW142R	306.0	12.5	.400	.0	0	.0
P-230	EW1	J-165	188.0	5.8	.400	.0	0	.0
P-231	EW159R	J-39	175.0	11.3	.400	.0	0	.0
P-232	EW42	EW43	293.0	5.8	.400	.0	0	.0
P-233	EW50	EW47	287.0	5.8	.400	.0	0	.0
P-234	EW43	EW44	287.0	5.8	.400	.0	0	.0
P-235	EW44	EW49R	212.0	5.8	.400	.0	0	.0
P-236	EW109	J-69	107.0	5.8	.400	.0	0	.0
P-237	EW159R	EW160R	262.0	11.3	.400	.0	0	.0
P-238	EW112	J-179	146.0	15.8	.400	.0	0	.0
P-239	EW185	EW161R	243.0	5.8	.400	.0	0	.0
P-24	J-25	EW167	115.0	5.8	.400	.0	0	.0
P-240	I-L-1	J-30	26.0	12.5	.400	.0	0	.0
P-241	EW116	J-74	244.0	11.3	.400	.0	0	.0
P-246	J-13	J-38	2125.0	21.0	.400	.0	0	.0
P-247	J-20	J-134	47.0	7.6	.400	.0	0	.0
P-248	J-20	J-13	55.0	7.6	.400	.0	0	.0
P-249	J-24	J-87	131.0	11.3	.400	.0	0	.0
P-25	J-25	EW103	200.0	12.5	.400	.0	0	.0
P-2503k	Open	O-L-1	146.0	12.5	.400	.0	0	.0
P-251	EW103	J-70	128.0	12.5	.400	.0	0	.0
P-253	J-40	EW173	105.0	5.8	.400	.0	0	.0
P-254	EW163	J-2	96.0	5.8	.400	.0	0	.0
P-255	J-33	J-174	16.0	7.6	.400	.0	0	.0
P-256	J-14	J-118	394.0	14.0	.400	.0	0	.0
P-257	J-14	J-37	124.0	21.0	.400	.0	0	.0
P-258	J-34	EW186	118.0	5.8	.400	.0	0	.0
P-259	J-33	J-42	96.0	12.5	.400	.0	0	.0
P-26	J-26	EW165	108.0	5.8	.400	.0	0	.0
P-260	J-36	J-47	319.0	11.3	.400	.0	0	.0
P-261	J-42	J-30	240.0	12.5	.400	.0	0	.0
P-262	J-47	J-44	286.0	11.3	.400	.0	0	.0
P-263	J-47	EW170	111.0	7.6	.400	.0	0	.0
P-264	EW170	EW185	224.0	5.8	.400	.0	0	.0
P-265	EW161R	EW158R	209.0	5.8	.400	.0	0	.0
P-266	J-44	J-49	72.0	11.3	.400	.0	0	.0
P-267	J-49	EW171	56.0	5.8	.400	.0	0	.0
P-268	J-49	J-54	259.0	11.3	.400	.0	0	.0
P-269	J-54	EW184	25.0	5.8	.400	.0	0	.0
P-27	J-26	J-28	322.0	12.5	.400	.0	0	.0
P-270	J-54	EW160R	284.0	11.3	.400	.0	0	.0
P-271	EW173	EW183	279.0	5.8	.400	.0	0	.0
P-275	J-3	J-6	340.0	11.3	.400	.0	0	.0

P-276	EW175	EW182	213.0	5.8	.400	.0	0	.0
P-277	J-6	EW175	118.0	5.8	.400	.0	0	.0
P-278	J-6	J-55	250.0	11.3	.400	.0	0	.0
P-279	EW176	EW181	297.0	5.8	.400	.0	0	.0
P-28	J-28	EW102	92.0	5.8	.400	.0	0	.0
P-280	J-55	EW176	114.0	5.8	.400	.0	0	.0
P-281	J-55	J-62	294.0	11.3	.400	.0	0	.0
P-282	J-58	EW177	58.0	5.8	.400	.0	0	.0
P-283	J-58	J-59	249.0	11.3	.400	.0	0	.0
P-284	J-59	EW180	123.0	5.8	.400	.0	0	.0
P-285	J-59	J-61	88.0	11.3	.400	.0	0	.0
P-286	J-61	EW179	100.0	5.8	.400	.0	0	.0
P-288	J-62	J-58	100.0	11.3	.400	.0	0	.0
P-289	J-62	J-66	179.0	11.3	.400	.0	0	.0
P-29	J-28	J-23	315.0	12.5	.400	.0	0	.0
P-290	J-66	J-21	189.0	14.0	.400	.0	0	.0
P-291	J-66	J-70	272.0	11.3	.400	.0	0	.0
P-292	J-70	J-26	60.0	12.5	.400	.0	0	.0
P-3	J-36	EW187	90.0	5.8	.400	.0	0	.0
P-30	J-32	J-18	237.0	15.8	.400	.0	0	.0
P-31	J-18	EW141R	193.0	5.8	.400	.0	0	.0
P-32	J-23	J-31	21.0	11.3	.400	.0	0	.0
P-33	J-23	J-37	174.0	14.0	.400	.0	0	.0
P-34	J-35	EW128R	66.0	5.8	.400	.0	0	.0
P-35	J-35	EW127R	322.0	7.6	.400	.0	0	.0
P-36	J-1	J-29	222.0	11.3	.400	.0	0	.0
P-37	J-17	J-14	248.0	21.0	.400	.0	0	.0
P-38	J-41	EW137R	55.0	5.8	.400	.0	0	.0
P-39	EW147	J-48	118.0	14.0	.400	.0	0	.0
P-4	J-2	EW162R	163.0	5.8	.400	.0	0	.0
P-40	J-19	J-48	78.0	12.5	.400	.0	0	.0
P-41	EW102	EW140R	513.0	5.8	.400	.0	0	.0
P-42	EW113	J-46	21.0	5.8	.400	.0	0	.0
P-43	J-43	J-33	39.0	12.5	.400	.0	0	.0
P-44	J-19	EW146	193.0	5.8	.400	.0	0	.0
P-45	J-53	J-51	356.0	11.3	.400	.0	0	.0
P-46	J-1	EW130	86.0	7.6	.400	.0	0	.0
P-47	EW124R	J-15	43.0	5.8	.400	.0	0	.0
P-48	EW154	EW153R	222.0	11.3	.400	.0	0	.0
P-49	J-48	J-50	235.0	12.5	.400	.0	0	.0
P-5	J-5	J-40	244.0	11.3	.400	.0	0	.0
P-50	J-50	EW155	105.0	11.3	.400	.0	0	.0
P-51	J-50	J-51	208.0	12.5	.400	.0	0	.0
P-52	J-51	EW156	118.0	5.8	.400	.0	0	.0
P-53	EW71	J-7	17.0	11.3	.400	.0	0	.0
P-54	J-53	EW163	155.0	5.8	.400	.0	0	.0
P-55	J-53	J-34	161.0	11.3	.400	.0	0	.0

P-56	J-34	J-36	285.0	11.3	.400	.0	0	.0
P-57	J-37	J-1	82.0	11.3	.400	.0	0	.0
P-58	EW126R	EW127R	257.0	7.6	.400	.0	0	.0
P-59	J-57	EW116	117.0	11.3	.400	.0	0	.0
P-6	J-5	EW172	110.0	5.8	.400	.0	0	.0
P-60	J-57	J-60	342.0	11.3	.400	.0	0	.0
P-61	J-38	EW66	127.0	5.8	.400	.0	0	.0
P-62	J-120	J-11	310.0	7.6	.400	.0	0	.0
P-63	J-60	EW115	116.0	5.8	.400	.0	0	.0
P-64	J-60	J-64	62.0	11.3	.400	.0	0	.0
P-65	J-64	EW107	133.0	5.8	.400	.0	0	.0
P-66	J-64	J-65	136.0	11.3	.400	.0	0	.0
P-67	J-65	EW114	115.0	5.8	.400	.0	0	.0
P-68	J-65	J-67	237.0	11.3	.400	.0	0	.0
P-69	J-67	EW108	81.0	5.8	.400	.0	0	.0
P-7	J-40	J-3	358.0	11.3	.400	.0	0	.0
P-70	J-67	J-63	116.0	11.3	.400	.0	0	.0
P-71	J-63	EW111A	112.0	5.8	.400	.0	0	.0
P-72	J-69	J-63	105.0	11.3	.400	.0	0	.0
P-73	J-69	J-71	88.0	11.3	.400	.0	0	.0
P-74	J-71	EW110	105.0	5.8	.400	.0	0	.0
P-75	J-71	J-73	35.0	11.3	.400	.0	0	.0
P-76	J-74	EW117	28.0	5.8	.400	.0	0	.0
P-77	J-74	J-75	222.0	11.3	.400	.0	0	.0
P-78	J-75	EW118	34.0	5.8	.400	.0	0	.0
P-79	J-75	J-77	281.0	11.3	.400	.0	0	.0
P-8	EW155	EW154	231.0	11.3	.400	.0	0	.0
P-80	J-77	EW119	38.0	5.8	.400	.0	0	.0
P-81	J-77	J-79	239.0	11.3	.400	.0	0	.0
P-82	J-79	EW120	30.0	5.8	.400	.0	0	.0
P-83	J-79	J-81	246.0	11.3	.400	.0	0	.0
P-84	J-81	EW121	43.0	5.8	.400	.0	0	.0
P-85	J-81	J-83	101.0	11.3	.400	.0	0	.0
P-86	J-83	J-73	388.0	11.3	.400	.0	0	.0
P-87	J-83	J-85	216.0	11.3	.400	.0	0	.0
P-88	J-85	EW122	165.0	5.8	.400	.0	0	.0
P-89	J-85	J-167	157.0	11.3	.400	.0	0	.0
P-9	J-78	J-10	111.0	14.0	.400	.0	0	.0
P-90	J-87	EW51	52.0	5.8	.400	.0	0	.0
P-91	J-87	J-89	160.0	11.3	.400	.0	0	.0
P-92	J-89	EW50	43.0	5.8	.400	.0	0	.0
P-93	J-89	J-90	182.0	11.3	.400	.0	0	.0
P-94	J-90	EW46	19.0	5.8	.400	.0	0	.0
P-95	J-90	J-92	159.0	11.3	.400	.0	0	.0
P-96	J-92	EW42	18.0	5.8	.400	.0	0	.0
P-97	J-92	J-94	176.0	11.3	.400	.0	0	.0
P-98	J-94	EW41	18.0	5.8	.400	.0	0	.0

P-99 J-94 J-96 176.0 11.3 .400 .0 0 .0

*** DATA FOR COMPRESSORS FOR THIS SYSTEM ***

COMPRESSOR ID # 1 IS DESCRIBED BY THE FOLLOWING DATA:

PRESSURE (USPU)	DISCHARGE (USFU)
.00	.000
-58.00	13196.000
-232.00	26392.000

JUNCTION NAME	NODE TITLE	ELEV	DEMAND (USFU)	FPN PRESSURE
3k Open F		.00	.00	-58.00
Enclosed		.00	.00	-58.00
EW1		.00	-11.17	
EW10		.00	-11.17	
EW101		.00	-55.58	
EW102		.00	-55.58	
EW103		.00	-55.58	
EW106		.00	-111.17	
EW107		.00	-111.17	
EW108		.00	-111.17	
EW109		.00	-111.17	
EW11		.00	-11.17	
EW110		.00	-111.17	
EW111A		.00	-111.17	
EW112		.00	-111.17	
EW113		.00	-55.58	
EW114		.00	-111.17	
EW115		.00	-111.17	
EW116		.00	-111.17	
EW117		.00	-111.17	
EW118		.00	-111.17	
EW119		.00	-111.17	
EW12		.00	-11.17	
EW120		.00	-111.17	
EW121		.00	-111.17	
EW122		.00	-55.58	
EW123		.00	-55.58	
EW124R		.00	-111.17	
EW125R		.00	-111.17	

EW126R	.00	-111.17
EW127R	.00	-111.17
EW128R	.00	-111.17
EW129	.00	-111.17
EW12A	.00	-11.17
EW13	.00	-11.17
EW130	.00	-55.58
EW131	.00	-111.17
EW132R	.00	-111.17
EW133R	.00	-111.17
EW134R	.00	-111.17
EW135R	.00	-111.17
EW136	.00	-55.58
EW137R	.00	-111.17
EW138R	.00	-111.17
EW139R	.00	-111.17
EW14	.00	-11.17
EW140R	.00	-111.17
EW141R	.00	-111.17
EW142R	.00	-111.17
EW143R	.00	-111.17
EW144R	.00	-111.17
EW145	.00	-111.17
EW146	.00	-55.58
EW147	.00	-55.58
EW148	.00	-111.17
EW149R	.00	-111.17
EW15	.00	-11.17
EW150R	.00	-111.17
EW151R	.00	-111.17
EW152R	.00	-111.17
EW153R	.00	-111.17
EW154	.00	-111.17
EW155	.00	-55.58
EW156	.00	-55.58
EW157	.00	-111.17
EW158R	.00	-111.17
EW159R	.00	-111.17
EW16	.00	-11.17
EW160R	.00	-111.17
EW161R	.00	-111.17
EW162R	.00	-111.17
EW163	.00	-55.58
EW165	.00	-55.58
EW167	.00	-111.17
EW17	.00	-11.17
EW170	.00	-55.58

EW171	.00	-55.58
EW172	.00	-55.58
EW173	.00	-55.58
EW174	.00	-55.58
EW175	.00	-55.58
EW176	.00	-55.58
EW177	.00	-55.58
EW178	.00	-55.58
EW179	.00	-111.17
EW18	.00	-11.17
EW180	.00	-111.17
EW181	.00	-111.17
EW182	.00	-111.17
EW183	.00	-111.17
EW184	.00	-111.17
EW185	.00	-111.17
EW186	.00	-55.58
EW187	.00	-55.58
EW19	.00	-11.17
EW2	.00	-11.17
EW20	.00	-11.17
EW21	.00	-11.17
EW22	.00	-11.17
EW23	.00	-11.17
EW24	.00	-11.17
EW25	.00	-11.17
EW26	.00	-11.17
EW27	.00	-11.17
EW28	.00	-11.17
EW29	.00	-11.17
EW3	.00	-11.17
EW30	.00	-11.17
EW31	.00	-11.17
EW32	.00	-11.17
EW33	.00	-11.17
EW34	.00	-11.17
EW35	.00	-11.17
EW36	.00	-11.17
EW37RR	.00	-11.17
EW38	.00	-11.17
EW39	.00	-11.17
EW4	.00	-11.17
EW40	.00	-11.17
EW41	.00	-11.17
EW42	.00	-11.17
EW43	.00	-11.17
EW44	.00	-11.17

EW45R	.00	-11.17
EW46	.00	-11.17
EW47	.00	-11.17
EW49R	.00	-11.17
EW50	.00	-11.17
EW51	.00	-11.17
EW6	.00	-11.17
EW61	.00	-11.17
EW62	.00	-11.17
EW63R	.00	-11.17
EW64R	.00	-11.17
EW65	.00	-11.17
EW66	.00	-11.17
EW67	.00	-11.17
EW68R	.00	-11.17
EW69	.00	-11.17
EW7	.00	-11.17
EW70	.00	-11.17
EW71	.00	-11.17
EW71R	.00	-11.17
EW72	.00	-11.17
EW8	.00	-11.17
EW9	.00	-11.17
J-1	.00	.00
J-10	.00	.00
J-100	.00	.00
J-103	.00	.00
J-106	.00	.00
J-109	.00	.00
J-11	.00	.00
J-117	.00	.00
J-118	.00	.00
J-12	.00	.00
J-120	.00	.00
J-125	.00	.00
J-127	.00	.00
J-129	.00	.00
J-13	.00	.00
J-131	.00	.00
J-134	.00	.00
J-135	.00	.00
J-138	.00	.00
J-14	.00	.00
J-140	.00	.00
J-141	.00	.00
J-144	.00	.00
J-147	.00	.00

J-15	.00	.00
J-153	.00	.00
J-154	.00	.00
J-156	.00	.00
J-158	.00	.00
J-16	.00	.00
J-162	.00	.00
J-165	.00	.00
J-167	.00	.00
J-17	.00	.00
J-170	.00	.00
J-172	.00	.00
J-173	.00	.00
J-174	.00	.00
J-175	.00	.00
J-176	.00	.00
J-177	.00	.00
J-179	.00	.00
J-18	.00	.00
J-19	.00	.00
J-2	.00	.00
J-20	.00	.00
J-21	.00	.00
J-22	.00	.00
J-23	.00	.00
J-24	.00	.00
J-25	.00	.00
J-26	.00	.00
J-27	.00	.00
J-28	.00	.00
J-29	.00	.00
J-3	.00	.00
J-30	.00	.00
J-31	.00	.00
J-32	.00	.00
J-33	.00	.00
J-34	.00	.00
J-35	.00	.00
J-36	.00	.00
J-37	.00	.00
J-38	.00	.00
J-39	.00	.00
J-4	.00	.00
J-40	.00	.00
J-41	.00	.00
J-42	.00	.00
J-43	.00	.00

J-44	.00	.00
J-46	.00	.00
J-47	.00	.00
J-48	.00	.00
J-49	.00	.00
J-5	.00	.00
J-50	.00	.00
J-51	.00	.00
J-53	.00	.00
J-54	.00	.00
J-55	.00	.00
J-57	.00	.00
J-58	.00	.00
J-59	.00	.00
J-6	.00	.00
J-60	.00	.00
J-61	.00	.00
J-62	.00	.00
J-63	.00	.00
J-64	.00	.00
J-65	.00	.00
J-66	.00	.00
J-67	.00	.00
J-68	.00	.00
J-69	.00	.00
J-7	.00	.00
J-70	.00	.00
J-71	.00	.00
J-72	.00	.00
J-73	.00	.00
J-74	.00	.00
J-75	.00	.00
J-76	.00	.00
J-77	.00	.00
J-78	.00	.00
J-79	.00	.00
J-8	.00	.00
J-80	.00	.00
J-81	.00	.00
J-83	.00	.00
J-85	.00	.00
J-87	.00	.00
J-89	.00	.00
J-9	.00	.00
J-90	.00	.00
J-92	.00	.00
J-94	.00	.00

J-96	.00	.00
J-99	.00	.00
O-L-1	.00	.00
I-L-1	.00	.00

===
Set = 0

=================== RESULTS FOR THIS SIMULATION FOLLOW =================

Solution was obtained in 14 trials
Flow Accuracy = .3928E-02[< .500E-02]
RV Accuracy = .0000E+00[< .100E-02]

PIPE NO.	NODE #1	NODE #2	FLOW (USFU)	LOSS (USPU)	VELOCITY (FT/S)	DENSITY (#/CF)	FRICTION FACTOR	AREA RATIO
P-1	J-44	J-5	-7.270	.00	.18	.075	.0000	
P-10	EW148	J-12	111.168	.00	1.77	.075	.0264	
P-100	J-96	EW40	-11.171	.00	1.02	.075	.0388	
P-101	J-96	J-99	550.507	.24	13.55	.075	.0194	
P-102	J-99	EW39	-11.171	.00	1.02	.075	.0388	
P-103	J-99	J-100	561.678	.28	13.83	.075	.0194	
P-104	J-100	EW38	-11.171	.00	1.02	.075	.0388	
P-105	J-100	EW37RR	572.850	.29	14.10	.075	.0194	
P-106	J-103	EW72	-11.171	.00	1.02	.075	.0388	
P-107	J-103	EW71	595.193	.29	14.65	.075	.0193	
P-108	EW123	J-170	241.398	.09	12.98	.075	.0214	
P-109	EW130	J-68	-481.193	.08	25.88	.075	.0199	
P-11	J-10	EW144R	-111.168	.00	1.77	.075	.0264	
P-110	J-106	EW70	-11.171	.00	1.02	.075	.0388	
P-111	J-106	J-117	628.707	.06	15.48	.075	.0191	
P-112	J-109	EW69	-11.171	.00	1.02	.075	.0388	
P-113	EW66	EW67	-33.514	.04	3.06	.075	.0294	
P-114	J-109	EW66	-670.027	.12	13.36	.075	.0190	
P-115	EW62	EW65	709.054	.23	17.46	.075	.0189	
P-116	EW65	EW66	720.226	.23	17.73	.075	.0189	
P-117	J-68	EW129	-111.168	.22	10.14	.075	.0236	
P-118	EW62	EW63R	-22.343	.02	2.04	.075	.0323	

P-119	EW62	J-118	-675.540	.16	16.63	.075	.0190
P-12	J-12	J-10	-725.248	.09	11.52	.075	.0189
P-120	J-38	J-17	-3511.777	.78	24.79	.075	.0159
P-121	J-57	J-29	1222.370	1.19	30.09	.075	.0180
P-122	J-118	EW61	-11.171	.00	1.02	.075	.0388
P-123	J-117	J-109	-681.198	.11	13.58	.075	.0190
P-124	J-4	J-129	67.029	.03	3.61	.075	.0265
P-125	J-13Enclosed		5318.739	.24	37.55	.075	.0154
P-126	J-11	J-9	-44.686	.00	2.40	.075	.0289
P-127	J-9	EW24	-11.171	.00	1.02	.075	.0388
P-128	J-9	EW26	-33.514	.01	3.06	.075	.0294
P-129	J-120	EW23	-11.171	.00	1.02	.075	.0388
P-13	J-76	EW143R	-111.168	.28	10.14	.075	.0236
P-130	J-117	J-13	1309.905	2.68	20.81	.075	.0177
P-131	J-41	EW138R	-111.168	.10	5.98	.075	.0241
P-132	J-17	J-29	-1568.494	.12	38.61	.075	.0176
P-133	J-125	EW21	-11.171	.00	1.02	.075	.0388
P-134	J-125	J-127	-234.601	.20	12.62	.075	.0215
P-135	J-127	EW20	-22.343	.00	2.04	.075	.0323
P-136	J-127	J-144	-212.258	.20	11.42	.075	.0218
P-137	J-129	J-125	-245.772	.26	13.22	.075	.0214
P-138	J-129	J-20	312.801	1.35	16.82	.075	.0208
P-139	J-131	EW35	-11.171	.00	1.02	.075	.0388
P-14	J-12	EW147	836.416	.17	13.29	.075	.0185
P-140	J-131	EW36	-11.171	.00	1.02	.075	.0388
P-141	J-134	J-131	-22.343	.01	2.04	.075	.0323
P-142	J-134	J-138	-67.029	.06	3.61	.075	.0265
P-143	J-135	EW33	-11.171	.00	1.02	.075	.0388
P-144	J-135	EW34	-11.171	.00	1.02	.075	.0388
P-145	J-138	J-135	-22.343	.01	2.04	.075	.0323
P-146	J-138	J-140	-44.686	.01	2.40	.075	.0289
P-147	J-140	EW31	-22.343	.00	2.04	.075	.0323
P-148	J-140	J-141	-22.343	.00	1.20	.075	.0343
P-149	J-141	EW30	-11.171	.00	1.02	.075	.0388
P-15	J-80	J-78	502.912	.07	7.99	.075	.0199
P-150	J-141	EW29	-11.171	.00	1.02	.075	.0388
P-151	J-144	EW19	-11.171	.00	1.02	.075	.0388
P-152	J-144	EW17	-201.086	.19	10.82	.075	.0220
P-153	EW17	EW18	-11.171	.01	1.02	.075	.0388
P-154	EW17	EW15	-178.743	.14	9.61	.075	.0223
P-155	J-147	EW14	-22.343	.00	2.04	.075	.0323
P-156	J-147	EW12	-145.229	.10	7.81	.075	.0230
P-157	EW12	EW12A	-11.171	.00	1.02	.075	.0388
P-158	EW12	EW13	-11.171	.01	1.02	.075	.0388
P-159	EW12	EW11	-111.715	.04	6.01	.075	.0241
P-16	J-16	EW133R	898.747	.06	11.28	.075	.0184
P-160	J-153	EW9	-22.343	.00	2.04	.075	.0323

P-161	J-153	J-154	-78.200	.03	4.21	.075	.0257
P-162	J-154	EW8	-11.171	.00	1.02	.075	.0388
P-163	J-154	J-156	-67.029	.02	3.61	.075	.0265
P-164	J-156	EW7	-11.171	.00	1.02	.075	.0388
P-165	J-156	J-158	-55.857	.02	3.00	.075	.0275
P-166	J-158	EW6	-11.171	.00	1.02	.075	.0388
P-167	J-158	J-162	-44.686	.03	2.40	.075	.0289
P-168	EW37RR	J-103	584.021	.31	14.38	.075	.0193
P-169	J-35	J-68	370.025	.61	19.90	.075	.0204
P-17	EW139R	J-16	583.792	.15	11.64	.075	.0194
P-170	J-162	EW4	-11.171	.00	1.02	.075	.0388
P-171	J-162	EW1	-33.514	.01	1.80	.075	.0309
P-172	J-165	EW3	-11.171	.00	1.02	.075	.0388
P-173	J-165	EW2	-11.171	.00	1.02	.075	.0388
P-174	J-167	J-24	438.792	.03	10.80	.075	.0200
P-175	J-167	J-27	-49.227	.00	1.21	.075	.0305
P-176	J-27	J-170	-122.602	.00	1.95	.075	.0253
P-177	J-30	J-19	-2344.673	.18	46.75	.075	.0170
P-178	EW101	EW131	-111.168	.23	10.14	.075	.0236
P-179	J-170	J-177	118.796	.00	1.89	.075	.0266
P-18	J-80	EW150R	-111.168	.06	10.14	.075	.0236
P-180	J-172	J-27	-73.375	.00	1.46	.075	.0275
P-181	J-172	J-173	121.757	.01	2.43	.075	.0254
P-182	J-174	J-42	305.774	.02	6.10	.075	.0213
P-183	J-173	J-174	192.168	.01	3.83	.075	.0230
P-184	J-175	J-43	18.552	.00	.37	.075	.0438
P-185	J-173	J-175	-70.411	.01	3.79	.075	.0259
P-186	J-176	J-175	88.963	.00	1.77	.075	.0270
P-187	J-177	J-172	48.382	.00	2.60	.075	.0305
P-188	J-176	J-177	-70.414	.00	1.12	.075	.0293
P-189	EW113	J-72	389.088	.01	9.58	.075	.0204
P-19	J-21	EW178	-55.584	.01	5.07	.075	.0265
P-190	J-15	EW123	185.814	.26	9.99	.075	.0222
P-191	J-179	J-176	18.549	.00	.23	.075	.0437
P-192	J-15	EW125R	-74.646	.04	4.02	.075	.0259
P-193	EW134R	J-16	314.955	.01	3.95	.075	.0217
P-194	J-32	EW133R	-1009.915	.15	12.68	.075	.0182
P-195	EW132R	J-32	111.168	.06	10.14	.075	.0236
P-196	J-18	J-31	1232.251	.11	15.47	.075	.0178
P-197	J-31	EW101	-166.752	.01	4.11	.075	.0234
P-198	EW135R	EW134R	203.787	.01	2.56	.075	.0237
P-199	EW136	J-72	55.584	.08	5.07	.075	.0265
P-2	J-2	EW157	-111.168	.21	10.14	.075	.0236
P-20	J-21	J-22	169.408	.01	2.69	.075	.0240
P-200	J-72	J-43	444.672	.04	10.95	.075	.0200
P-201	J-46	EW145	-111.168	.20	10.14	.075	.0236
P-202	J-46	J-41	-222.336	.26	11.96	.075	.0217

P-203	EW153R	J-8	-368.942	.12	9.08	.075	.0205
P-204	J-8	EW152R	-111.168	.07	10.14	.075	.0236
P-205	J-8	J-39	-257.774	.02	6.35	.075	.0217
P-206	J-3	EW174	-55.584	.03	5.07	.075	.0265
P-207	EW135R	EW112	-92.619	.00	1.16	.075	.0283
P-208	EW125R	EW126R	36.521	.01	1.96	.075	.0302
P-209	J-22	J-76	280.576	.02	4.46	.075	.0218
P-21	EW139R	EW142R	-472.624	.12	9.42	.075	.0199
P-210	J-76	J-80	391.744	.01	6.22	.075	.0206
P-211	EW149R	J-78	111.168	.02	10.14	.075	.0236
P-212	J-39	J-61	222.116	.03	5.47	.075	.0222
P-213	EW20	EW25	-11.171	.00	1.02	.075	.0388
P-214	J-4	J-120	-55.857	.02	3.00	.075	.0275
P-215	J-4	EW22	-11.171	.00	1.02	.075	.0388
P-216	EW26	EW27	-22.343	.02	2.04	.075	.0323
P-217	EW27	EW28	-11.171	.01	1.02	.075	.0388
P-218	J-7	J-106	617.535	.32	15.20	.075	.0192
P-219	J-7	EW71R	-11.171	.00	1.02	.075	.0388
P-22	J-22	EW151R	-111.168	.13	10.14	.075	.0236
P-220	EW67	EW68R	-22.343	.01	2.04	.075	.0323
P-221	EW63R	EW64R	-11.171	.00	1.02	.075	.0388
P-222	EW68R	EW45R	-11.171	.00	1.02	.075	.0388
P-223	EW107	EW106	-59.507	.08	5.43	.075	.0262
P-224	EW106	EW109	51.661	.07	4.71	.075	.0269
P-225	EW31	EW32	-11.171	.00	1.02	.075	.0388
P-226	EW14	EW16	-11.171	.00	1.02	.075	.0388
P-227	EW15	J-147	-167.572	.11	9.01	.075	.0225
P-228	EW11	J-153	-100.543	.04	5.41	.075	.0245
P-229	EW9	EW10	-11.171	.01	1.02	.075	.0388
P-23	J-25	EW142R	361.457	.07	7.21	.075	.0207
P-230	EW1	J-165	-22.343	.01	2.04	.075	.0323
P-231	EW159R	J-39	479.889	.12	11.81	.075	.0198
P-232	EW42	EW43	-33.514	.04	3.06	.075	.0294
P-233	EW50	EW47	-11.171	.01	1.02	.075	.0388
P-234	EW43	EW44	-22.343	.02	2.04	.075	.0323
P-235	EW44	EW49R	-11.171	.00	1.02	.075	.0388
P-236	EW109	J-69	162.829	.24	14.85	.075	.0225
P-237	EW159R	EW160R	-368.721	.11	9.08	.075	.0205
P-238	EW112	J-179	18.549	.00	.23	.075	.0437
P-239	EW185	EW161R	-222.336	1.00	20.28	.075	.0217
P-24	J-25	EW167	-111.168	.13	10.14	.075	.0236
P-240	I-L-1	J-30	-3000.064	.34	59.82	.075	.0168
P-241	EW116	J-74	-477.755	.16	11.76	.075	.0198
P-246	J-13	J-38	-3606.661	2.81	25.46	.075	.0159
P-247	J-20	J-134	-89.372	.01	4.81	.075	.0250
P-248	J-20	J-13	402.173	.18	21.63	.075	.0202
P-249	J-24	J-87	438.792	.07	10.80	.075	.0200

P-25	J-25	EW103	-250.289	.02	4.99	.075	.0220
P-2503k	Open F	O-L-1	-3000.064	1.89	59.82	.075	.0168
P-251	EW103	J-70	-194.705	.01	3.88	.075	.0230
P-253	J-40	EW173	-166.752	.25	15.21	.075	.0224
P-254	EW163	J-2	-222.336	.39	20.28	.075	.0217
P-255	J-33	J-174	113.606	.01	6.11	.075	.0241
P-256	J-14	J-118	664.368	.16	10.55	.075	.0191
P-257	J-14	J-37	-2607.651	.09	18.41	.075	.0164
P-258	J-34	EW186	-55.584	.04	5.07	.075	.0265
P-259	J-33	J-42	349.618	.02	6.97	.075	.0208
P-26	J-26	EW165	-55.584	.03	5.07	.075	.0265
P-260	J-36	J-47	-305.556	.09	7.52	.075	.0211
P-261	J-42	J-30	655.392	.17	13.07	.075	.0191
P-262	J-47	J-44	83.532	.01	2.06	.075	.0269
P-263	J-47	EW170	-389.088	.35	20.93	.075	.0203
P-264	EW170	EW185	-333.504	1.99	30.42	.075	.0209
P-265	EW161R	EW158R	-111.168	.23	10.14	.075	.0236
P-266	J-44	J-49	90.802	.00	2.24	.075	.0265
P-267	J-49	EW171	-55.584	.02	5.07	.075	.0265
P-268	J-49	J-54	146.386	.02	3.60	.075	.0240
P-269	J-54	EW184	-111.168	.03	10.14	.075	.0236
P-27	J-26	J-28	851.244	.37	16.97	.075	.0185
P-270	J-54	EW160R	257.553	.06	6.34	.075	.0217
P-271	EW173	EW183	-111.168	.31	10.14	.075	.0236
P-275	J-3	J-6	270.650	.08	6.66	.075	.0215
P-276	EW175	EW182	-111.168	.24	10.14	.075	.0236
P-277	J-6	EW175	-166.752	.28	15.21	.075	.0224
P-278	J-6	J-55	437.402	.14	10.77	.075	.0200
P-279	EW176	EW181	-111.168	.33	10.14	.075	.0236
P-28	J-28	EW102	-166.752	.22	15.21	.075	.0224
P-280	J-55	EW176	-166.752	.27	15.21	.075	.0224
P-281	J-55	J-62	604.154	.30	14.87	.075	.0192
P-282	J-58	EW177	-55.584	.02	5.07	.075	.0265
P-283	J-58	J-59	-444.451	.14	10.94	.075	.0200
P-284	J-59	EW180	-111.168	.14	10.14	.075	.0236
P-285	J-59	J-61	-333.283	.03	8.20	.075	.0208
P-286	J-61	EW179	-111.168	.11	10.14	.075	.0236
P-288	J-62	J-58	-500.035	.07	12.31	.075	.0197
P-289	J-62	J-66	1104.189	.57	27.18	.075	.0181
P-29	J-28	J-23	1017.996	.51	20.30	.075	.0182
P-290	J-66	J-21	113.824	.00	1.81	.075	.0261
P-291	J-66	J-70	990.364	.71	24.38	.075	.0183
P-292	J-70	J-26	795.660	.06	15.87	.075	.0186
P-3	J-36	EW187	-55.584	.03	5.07	.075	.0265
P-30	J-32	J-18	1121.083	.14	14.07	.075	.0180
P-31	J-18	EW141R	-111.168	.22	10.14	.075	.0236
P-32	J-23	J-31	-1399.003	.11	34.44	.075	.0178

P-33	J-23	J-37	2416.998	.83	38.39	.075	.0168
P-34	J-35	EW128R	-111.168	.07	10.14	.075	.0236
P-35	J-35	EW127R	-258.857	.47	13.92	.075	.0212
P-36	J-1	J-29	346.124	.08	8.52	.075	.0207
P-37	J-17	J-14	-1943.283	.10	13.72	.075	.0169
P-38	J-41	EW137R	-111.168	.06	10.14	.075	.0236
P-39	EW147	J-48	892.000	.08	14.17	.075	.0184
P-4	J-2	EW162R	-111.168	.18	10.14	.075	.0236
P-40	J-19	J-48	-2289.089	.60	45.65	.075	.0170
P-41	EW102	EW140R	-111.168	.57	10.14	.075	.0236
P-42	EW113	J-46	-333.504	.19	30.42	.075	.0209
P-43	J-43	J-33	463.224	.01	9.24	.075	.0200
P-44	J-19	EW146	-55.584	.06	5.07	.075	.0265
P-45	J-53	J-51	694.643	.47	17.10	.075	.0189
P-46	J-1	EW130	-536.777	.50	28.87	.075	.0197
P-47	EW124R	J-15	111.168	.05	10.14	.075	.0236
P-48	EW154	EW153R	-480.110	.15	11.82	.075	.0198
P-49	J-48	J-50	-1397.089	.69	27.86	.075	.0177
P-5	J-5	J-40	48.314	.00	1.19	.075	.0306
P-50	J-50	EW155	-646.861	.12	15.92	.075	.0191
P-51	J-50	J-51	-750.227	.19	14.96	.075	.0188
P-52	J-51	EW156	-55.584	.04	5.07	.075	.0265
P-53	EW71	J-7	606.364	.02	14.93	.075	.0192
P-54	J-53	EW163	-277.920	.97	25.35	.075	.0212
P-55	J-53	J-34	-416.724	.08	10.26	.075	.0202
P-56	J-34	J-36	-361.140	.11	8.89	.075	.0206
P-57	J-37	J-1	-190.653	.01	4.69	.075	.0228
P-58	EW126R	EW127R	147.689	.13	7.94	.075	.0230
P-59	J-57	EW116	-588.923	.11	14.50	.075	.0193
P-6	J-5	EW172	-55.584	.03	5.07	.075	.0265
P-60	J-57	J-60	-633.447	.38	15.59	.075	.0191
P-61	J-38	EW66	-94.885	.11	8.65	.075	.0242
P-62	J-120	J-11	-44.686	.02	2.40	.075	.0289
P-63	J-60	EW115	-111.168	.13	10.14	.075	.0236
P-64	J-60	J-64	-522.279	.05	12.86	.075	.0196
P-65	J-64	EW107	-170.675	.33	15.57	.075	.0223
P-66	J-64	J-65	-351.604	.05	8.66	.075	.0207
P-67	J-65	EW114	-111.168	.13	10.14	.075	.0236
P-68	J-65	J-67	-240.436	.04	5.92	.075	.0219
P-69	J-67	EW108	-111.168	.09	10.14	.075	.0236
P-7	J-40	J-3	215.066	.05	5.29	.075	.0223
P-70	J-67	J-63	-129.268	.01	3.18	.075	.0246
P-71	J-63	EW111A	-111.168	.13	10.14	.075	.0236
P-72	J-69	J-63	18.100	.00	.45	.075	.0405
P-73	J-69	J-71	144.729	.01	3.56	.075	.0240
P-74	J-71	EW110	-111.168	.12	10.14	.075	.0236
P-75	J-71	J-73	255.896	.01	6.30	.075	.0217

P-76	J-74	EW117	-111.168	.03	10.14	.075	.0236
P-77	J-74	J-75	-366.587	.09	9.02	.075	.0205
P-78	J-75	EW118	-111.168	.04	10.14	.075	.0236
P-79	J-75	J-77	-255.419	.06	6.29	.075	.0217
P-8	EW155	EW154	-591.277	.23	14.56	.075	.0193
P-80	J-77	EW119	-111.168	.04	10.14	.075	.0236
P-81	J-77	J-79	-144.251	.02	3.55	.075	.0241
P-82	J-79	EW120	-111.168	.03	10.14	.075	.0236
P-83	J-79	J-81	-33.084	.00	.81	.075	.0340
P-84	J-81	EW121	-111.168	.05	10.14	.075	.0236
P-85	J-81	J-83	78.084	.00	1.92	.075	.0274
P-86	J-83	J-73	-255.896	.08	6.30	.075	.0217
P-87	J-83	J-85	333.981	.07	8.22	.075	.0208
P-88	J-85	EW122	-55.584	.05	5.07	.075	.0265
P-89	J-85	J-167	389.565	.07	9.59	.075	.0203
P-9	J-78	J-10	614.080	.04	9.75	.075	.0193
P-90	J-87	EW51	-11.171	.00	1.02	.075	.0388
P-91	J-87	J-89	449.963	.09	11.08	.075	.0199
P-92	J-89	EW50	-22.343	.00	2.04	.075	.0323
P-93	J-89	J-90	472.306	.12	11.63	.075	.0198
P-94	J-90	EW46	-11.171	.00	1.02	.075	.0388
P-95	J-90	J-92	483.478	.11	11.90	.075	.0198
P-96	J-92	EW42	-44.686	.00	4.08	.075	.0277
P-97	J-92	J-94	528.164	.14	13.00	.075	.0195
P-98	J-94	EW41	-11.171	.00	1.02	.075	.0388
P-99	J-94	J-96	539.335	.14	13.28	.075	.0195
3k Open F	3k Open F	3k Open F	-3000.064	.00	.01	.075	.0331
Enclosed	Enclosed	Enclosed	-5318.739	.00	.02	.075	.0283

THE COMPRESSOR (PUMP) IN LINE L-1 OPERATES AT -2.99 (USU)

L-1	I-L-1	O-L-1	3000.064	.00	23.37	.075	.0137

JUNCTION NAME	NODE TITLE	DEMAND (USFU)	PRESSURE (USPU)	PRESSURE (PSIA)	PRESSURE (PSIG)	DENSITY #/CF
3k Open Fl		.00	-58.00	12.60	-2.09	.075
Enclosed F		.00	-58.00	12.60	-2.09	.075
EW1		-11.17	-54.84	12.72	-1.98	.075
EW10		-11.17	-54.94	12.71	-1.98	.075
EW101		-55.58	-53.04	12.78	-1.91	.075
EW102		-55.58	-52.43	12.80	-1.89	.075
EW103		-55.58	-52.23	12.81	-1.88	.075
EW106		-111.17	-52.02	12.82	-1.88	.075
EW107		-111.17	-52.11	12.82	-1.88	.075
EW108		-111.17	-52.25	12.81	-1.89	.075

EW109	-111.17	-52.09	12.82	-1.88	.075
EW11	-11.17	-54.98	12.71	-1.98	.075
EW110	-111.17	-52.23	12.81	-1.88	.075
EW111A	-111.17	-52.21	12.81	-1.88	.075
EW112	-111.17	-52.57	12.80	-1.90	.075
EW113	-55.58	-52.52	12.80	-1.90	.075
EW114	-111.17	-52.26	12.81	-1.89	.075
EW115	-111.17	-52.36	12.81	-1.89	.075
EW116	-111.17	-52.75	12.79	-1.90	.075
EW117	-111.17	-52.56	12.80	-1.90	.075
EW118	-111.17	-52.47	12.80	-1.89	.075
EW119	-111.17	-52.41	12.80	-1.89	.075
EW12	-11.17	-55.03	12.71	-1.99	.075
EW120	-111.17	-52.40	12.81	-1.89	.075
EW121	-111.17	-52.38	12.81	-1.89	.075
EW122	-55.58	-52.45	12.80	-1.89	.075
EW123	-55.58	-52.48	12.80	-1.89	.075
EW124R	-111.17	-52.17	12.81	-1.88	.075
EW125R	-111.17	-52.18	12.81	-1.88	.075
EW126R	-111.17	-52.19	12.81	-1.88	.075
EW127R	-111.17	-52.32	12.81	-1.89	.075
EW128R	-111.17	-52.71	12.79	-1.90	.075
EW129	-111.17	-53.17	12.78	-1.92	.075
EW12A	-11.17	-55.02	12.71	-1.99	.075
EW13	-11.17	-55.02	12.71	-1.99	.075
EW130	-55.58	-53.48	12.77	-1.93	.075
EW131	-111.17	-52.81	12.79	-1.91	.075
EW132R	-111.17	-52.74	12.79	-1.90	.075
EW133R	-111.17	-52.65	12.80	-1.90	.075
EW134R	-111.17	-52.58	12.80	-1.90	.075
EW135R	-111.17	-52.57	12.80	-1.90	.075
EW136	-55.58	-52.45	12.80	-1.89	.075
EW137R	-111.17	-52.01	12.82	-1.88	.075
EW138R	-111.17	-51.97	12.82	-1.88	.075
EW139R	-111.17	-52.44	12.80	-1.89	.075
EW14	-11.17	-55.13	12.71	-1.99	.075
EW140R	-111.17	-51.86	12.82	-1.87	.075
EW141R	-111.17	-52.73	12.79	-1.90	.075
EW142R	-111.17	-52.33	12.81	-1.89	.075
EW143R	-111.17	-51.27	12.85	-1.85	.075
EW144R	-111.17	-51.65	12.83	-1.86	.075
EW145	-111.17	-52.13	12.81	-1.88	.075
EW146	-55.58	-52.53	12.80	-1.90	.075
EW147	-55.58	-51.92	12.82	-1.87	.075
EW148	-111.17	-51.75	12.83	-1.87	.075
EW149R	-111.17	-51.59	12.83	-1.86	.075
EW15	-11.17	-55.24	12.70	-1.99	.075

EW150R	-111.17	-51.49	12.84	-1.86	.075
EW151R	-111.17	-51.40	12.84	-1.85	.075
EW152R	-111.17	-50.63	12.87	-1.83	.075
EW153R	-111.17	-50.81	12.86	-1.83	.075
EW154	-111.17	-50.96	12.86	-1.84	.075
EW155	-55.58	-51.18	12.85	-1.85	.075
EW156	-55.58	-51.08	12.85	-1.84	.075
EW157	-111.17	-49.07	12.93	-1.77	.075
EW158R	-111.17	-46.79	13.01	-1.69	.075
EW159R	-111.17	-50.56	12.87	-1.82	.075
EW16	-11.17	-55.12	12.71	-1.99	.075
EW160R	-111.17	-50.45	12.88	-1.82	.075
EW161R	-111.17	-47.02	13.00	-1.70	.075
EW162R	-111.17	-49.10	12.92	-1.77	.075
EW163	-55.58	-49.67	12.90	-1.79	.075
EW165	-55.58	-52.25	12.81	-1.89	.075
EW167	-111.17	-52.13	12.81	-1.88	.075
EW17	-11.17	-55.38	12.70	-2.00	.075
EW170	-55.58	-50.01	12.89	-1.80	.075
EW171	-55.58	-50.36	12.88	-1.82	.075
EW172	-55.58	-50.34	12.88	-1.82	.075
EW173	-55.58	-50.12	12.89	-1.81	.075
EW174	-55.58	-50.40	12.88	-1.82	.075
EW175	-55.58	-50.22	12.88	-1.81	.075
EW176	-55.58	-50.37	12.88	-1.82	.075
EW177	-55.58	-50.85	12.86	-1.84	.075
EW178	-55.58	-51.51	12.84	-1.86	.075
EW179	-111.17	-50.59	12.87	-1.83	.075
EW18	-11.17	-55.37	12.70	-2.00	.075
EW180	-111.17	-50.59	12.87	-1.83	.075
EW181	-111.17	-50.04	12.89	-1.81	.075
EW182	-111.17	-49.98	12.89	-1.80	.075
EW183	-111.17	-49.81	12.90	-1.80	.075
EW184	-111.17	-50.36	12.88	-1.82	.075
EW185	-111.17	-48.02	12.96	-1.73	.075
EW186	-55.58	-50.53	12.87	-1.82	.075
EW187	-55.58	-50.43	12.88	-1.82	.075
EW19	-11.17	-55.56	12.69	-2.01	.075
EW2	-11.17	-54.83	12.72	-1.98	.075
EW20	-11.17	-55.76	12.68	-2.01	.075
EW21	-11.17	-55.96	12.68	-2.02	.075
EW22	-11.17	-56.19	12.67	-2.03	.075
EW23	-11.17	-56.18	12.67	-2.03	.075
EW24	-11.17	-56.15	12.67	-2.03	.075
EW25	-11.17	-55.75	12.68	-2.01	.075
EW26	-11.17	-56.14	12.67	-2.03	.075
EW27	-11.17	-56.12	12.67	-2.03	.075

EW28	-11.17	-56.11	12.67	-2.03	.075
EW29	-11.17	-57.50	12.62	-2.07	.075
EW3	-11.17	-54.83	12.72	-1.98	.075
EW30	-11.17	-57.50	12.62	-2.08	.075
EW31	-11.17	-57.50	12.62	-2.08	.075
EW32	-11.17	-57.50	12.62	-2.08	.075
EW33	-11.17	-57.50	12.62	-2.08	.075
EW34	-11.17	-57.50	12.62	-2.08	.075
EW35	-11.17	-57.56	12.62	-2.08	.075
EW36	-11.17	-57.55	12.62	-2.08	.075
EW37RR	-11.17	-54.09	12.74	-1.95	.075
EW38	-11.17	-53.80	12.75	-1.94	.075
EW39	-11.17	-53.52	12.76	-1.93	.075
EW4	-11.17	-54.85	12.72	-1.98	.075
EW40	-11.17	-53.27	12.77	-1.92	.075
EW41	-11.17	-53.13	12.78	-1.92	.075
EW42	-11.17	-52.99	12.78	-1.91	.075
EW43	-11.17	-52.95	12.79	-1.91	.075
EW44	-11.17	-52.93	12.79	-1.91	.075
EW45R	-11.17	-54.79	12.72	-1.98	.075
EW46	-11.17	-52.88	12.79	-1.91	.075
EW47	-11.17	-52.76	12.79	-1.90	.075
EW49R	-11.17	-52.93	12.79	-1.91	.075
EW50	-11.17	-52.77	12.79	-1.90	.075
EW51	-11.17	-52.67	12.80	-1.90	.075
EW6	-11.17	-54.88	12.72	-1.98	.075
EW61	-11.17	-54.23	12.74	-1.96	.075
EW62	-11.17	-54.40	12.73	-1.96	.075
EW63R	-11.17	-54.38	12.73	-1.96	.075
EW64R	-11.17	-54.38	12.73	-1.96	.075
EW65	-11.17	-54.63	12.72	-1.97	.075
EW66	-11.17	-54.85	12.72	-1.98	.075
EW67	-11.17	-54.81	12.72	-1.98	.075
EW68R	-11.17	-54.80	12.72	-1.98	.075
EW69	-11.17	-54.97	12.71	-1.98	.075
EW7	-11.17	-54.89	12.72	-1.98	.075
EW70	-11.17	-55.02	12.71	-1.99	.075
EW71	-11.17	-54.68	12.72	-1.97	.075
EW71R	-11.17	-54.70	12.72	-1.97	.075
EW72	-11.17	-54.40	12.73	-1.96	.075
EW8	-11.17	-54.91	12.71	-1.98	.075
EW9	-11.17	-54.94	12.71	-1.98	.075
J-1	.00	-53.98	12.75	-1.95	.075
J-10	.00	-51.65	12.83	-1.86	.075
J-100	.00	-53.80	12.75	-1.94	.075
J-103	.00	-54.40	12.73	-1.96	.075
J-106	.00	-55.02	12.71	-1.99	.075

J-109	.00	-54.97	12.71	-1.98	.075
J-11	.00	-56.16	12.67	-2.03	.075
J-117	.00	-55.09	12.71	-1.99	.075
J-118	.00	-54.24	12.74	-1.96	.075
J-12	.00	-51.75	12.83	-1.87	.075
J-120	.00	-56.18	12.67	-2.03	.075
J-125	.00	-55.96	12.68	-2.02	.075
J-127	.00	-55.76	12.68	-2.01	.075
J-129	.00	-56.23	12.67	-2.03	.075
J-13	.00	-57.76	12.61	-2.08	.075
J-131	.00	-57.56	12.62	-2.08	.075
J-134	.00	-57.57	12.62	-2.08	.075
J-135	.00	-57.50	12.62	-2.08	.075
J-138	.00	-57.51	12.62	-2.08	.075
J-14	.00	-54.08	12.74	-1.95	.075
J-140	.00	-57.50	12.62	-2.08	.075
J-141	.00	-57.50	12.62	-2.08	.075
J-144	.00	-55.56	12.69	-2.01	.075
J-147	.00	-55.13	12.71	-1.99	.075
J-15	.00	-52.22	12.81	-1.88	.075
J-153	.00	-54.94	12.71	-1.98	.075
J-154	.00	-54.91	12.71	-1.98	.075
J-156	.00	-54.89	12.71	-1.98	.075
J-158	.00	-54.88	12.72	-1.98	.075
J-16	.00	-52.59	12.80	-1.90	.075
J-162	.00	-54.85	12.72	-1.98	.075
J-165	.00	-54.83	12.72	-1.98	.075
J-167	.00	-52.57	12.80	-1.90	.075
J-17	.00	-54.18	12.74	-1.96	.075
J-170	.00	-52.57	12.80	-1.90	.075
J-172	.00	-52.58	12.80	-1.90	.075
J-173	.00	-52.58	12.80	-1.90	.075
J-174	.00	-52.59	12.80	-1.90	.075
J-175	.00	-52.58	12.80	-1.90	.075
J-176	.00	-52.57	12.80	-1.90	.075
J-177	.00	-52.57	12.80	-1.90	.075
J-179	.00	-52.57	12.80	-1.90	.075
J-18	.00	-52.95	12.79	-1.91	.075
J-19	.00	-52.59	12.80	-1.90	.075
J-2	.00	-49.28	12.92	-1.78	.075
J-20	.00	-57.58	12.62	-2.08	.075
J-21	.00	-51.52	12.84	-1.86	.075
J-22	.00	-51.53	12.84	-1.86	.075
J-23	.00	-53.16	12.78	-1.92	.075
J-24	.00	-52.60	12.80	-1.90	.075
J-25	.00	-52.25	12.81	-1.89	.075
J-26	.00	-52.28	12.81	-1.89	.075

J-27	.00	-52.57	12.80	-1.90	.075
J-28	.00	-52.65	12.80	-1.90	.075
J-29	.00	-54.06	12.75	-1.95	.075
J-3	.00	-50.43	12.88	-1.82	.075
J-30	.00	-52.78	12.79	-1.90	.075
J-31	.00	-53.05	12.78	-1.91	.075
J-32	.00	-52.80	12.79	-1.91	.075
J-33	.00	-52.59	12.80	-1.90	.075
J-34	.00	-50.56	12.87	-1.82	.075
J-35	.00	-52.79	12.79	-1.91	.075
J-36	.00	-50.45	12.88	-1.82	.075
J-37	.00	-53.99	12.75	-1.95	.075
J-38	.00	-54.96	12.71	-1.98	.075
J-39	.00	-50.67	12.87	-1.83	.075
J-4	.00	-56.19	12.67	-2.03	.075
J-40	.00	-50.37	12.88	-1.82	.075
J-41	.00	-52.07	12.82	-1.88	.075
J-42	.00	-52.61	12.80	-1.90	.075
J-43	.00	-52.58	12.80	-1.90	.075
J-44	.00	-50.37	12.88	-1.82	.075
J-46	.00	-52.33	12.81	-1.89	.075
J-47	.00	-50.36	12.88	-1.82	.075
J-48	.00	-52.00	12.82	-1.88	.075
J-49	.00	-50.37	12.88	-1.82	.075
J-5	.00	-50.37	12.88	-1.82	.075
J-50	.00	-51.31	12.84	-1.85	.075
J-51	.00	-51.12	12.85	-1.84	.075
J-53	.00	-50.65	12.87	-1.83	.075
J-54	.00	-50.39	12.88	-1.82	.075
J-55	.00	-50.64	12.87	-1.83	.075
J-57	.00	-52.87	12.79	-1.91	.075
J-58	.00	-50.87	12.86	-1.84	.075
J-59	.00	-50.73	12.87	-1.83	.075
J-6	.00	-50.50	12.87	-1.82	.075
J-60	.00	-52.49	12.80	-1.89	.075
J-61	.00	-50.70	12.87	-1.83	.075
J-62	.00	-50.94	12.86	-1.84	.075
J-63	.00	-52.34	12.81	-1.89	.075
J-64	.00	-52.44	12.80	-1.89	.075
J-65	.00	-52.39	12.81	-1.89	.075
J-66	.00	-51.52	12.84	-1.86	.075
J-67	.00	-52.35	12.81	-1.89	.075
J-68	.00	-53.39	12.77	-1.93	.075
J-69	.00	-52.34	12.81	-1.89	.075
J-7	.00	-54.70	12.72	-1.97	.075
J-70	.00	-52.22	12.81	-1.88	.075
J-71	.00	-52.34	12.81	-1.89	.075

J-72	.00	-52.53	12.80	-1.90	.075
J-73	.00	-52.35	12.81	-1.89	.075
J-74	.00	-52.59	12.80	-1.90	.075
J-75	.00	-52.51	12.80	-1.89	.075
J-76	.00	-51.54	12.84	-1.86	.075
J-77	.00	-52.45	12.80	-1.89	.075
J-78	.00	-51.61	12.83	-1.86	.075
J-79	.00	-52.43	12.80	-1.89	.075
J-8	.00	-50.70	12.87	-1.83	.075
J-80	.00	-51.55	12.84	-1.86	.075
J-81	.00	-52.43	12.80	-1.89	.075
J-83	.00	-52.43	12.80	-1.89	.075
J-85	.00	-52.50	12.80	-1.89	.075
J-87	.00	-52.67	12.80	-1.90	.075
J-89	.00	-52.77	12.79	-1.90	.075
J-9	.00	-56.16	12.67	-2.03	.075
J-90	.00	-52.89	12.79	-1.91	.075
J-92	.00	-52.99	12.78	-1.91	.075
J-94	.00	-53.13	12.78	-1.92	.075
J-96	.00	-53.28	12.77	-1.92	.075
J-99	.00	-53.52	12.76	-1.93	.075
O-L-1	.00	-56.11	12.67	-2.03	.075
I-L-1	.00	-53.11	12.78	-1.92	.075

* This designates the use of default density in a low pressure region

THE NET SYSTEM DEMAND (USFU) = -8318.808

SUMMARY OF INFLOWS(+).AND.OUTFLOWS(-) :

NAME	FLOW (USFU)	FPN TITLE
3k Open	-3000.0	3k Open Flar
Enclosed	-5318.7	Enclosed Fla

SUMMARY OF MINIMUM.AND.MAXIMUM VELOCITIES (FT/S)

MINIMUM		MAXIMUM	
3k Open	.01	P-250	59.82
Enclosed	.02	P-177	46.75
P-1	.18	P-40	45.65
P-191	.23	P-132	38.61

P-184 .37 P-33 38.39

SUMMARY OF MINIMUM.AND.MAXIMUM LOSS/1000. (PSI)

MINIMUM MAXIMUM

P-1	.00	P-240	.47
3k Open	.00	P-250	.47
Enclosed	.00	P-42	.32
P-191	.00	P-264	.32
P-238	.00	P-177	.29

SUMMARY OF MINIMUM.AND.MAXIMUM PRESSURES (USPU)

MINIMUM MAXIMUM

3k Open	-58.00	EW158R	-46.79
J-13	-57.76	EW161R	-47.02
J-20	-57.58	EW185	-48.02
J-134	-57.57	EW157	-49.07
J-131	-57.56	EW162R	-49.10

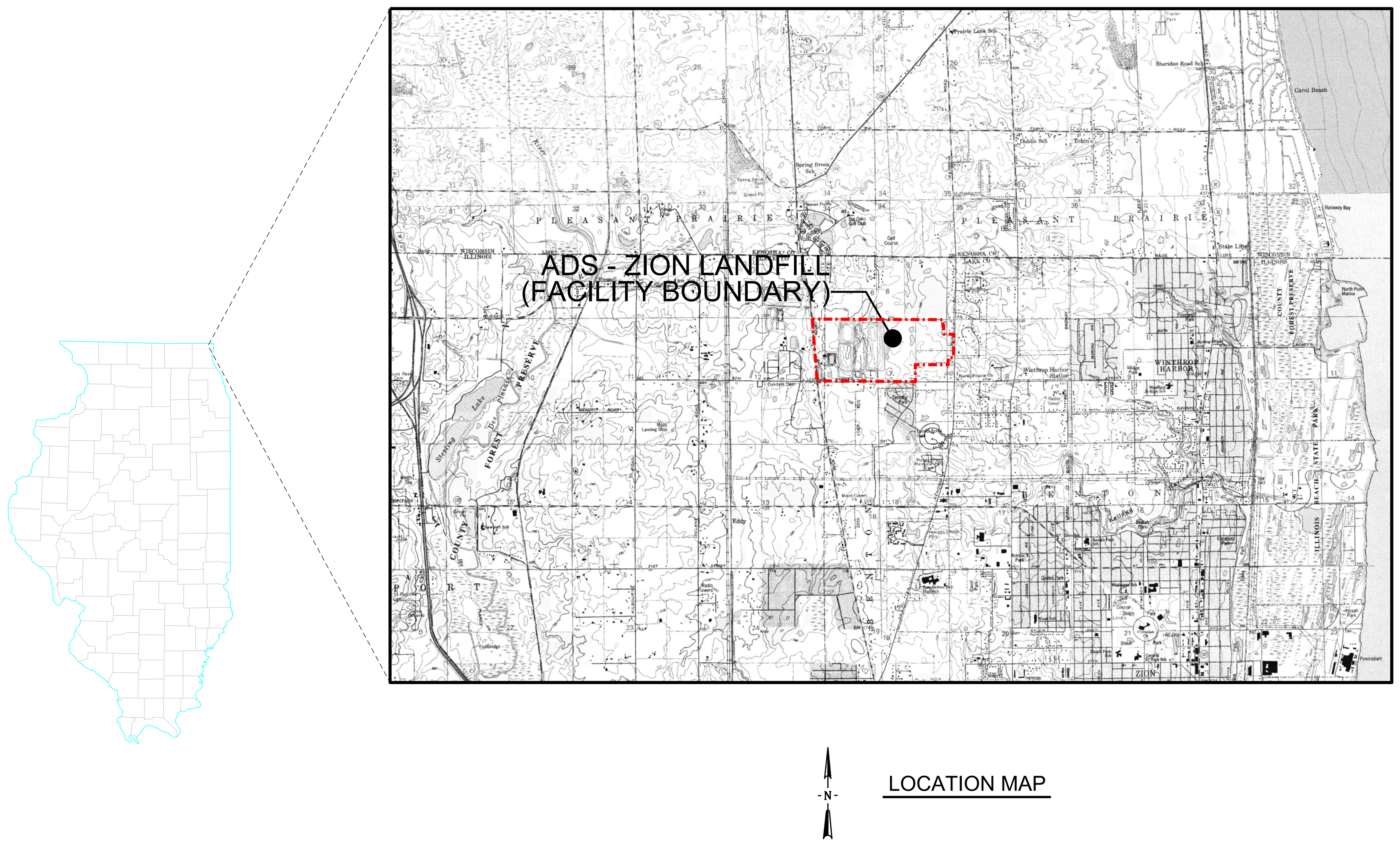
************************* END OF KYGAS SIMULATION ************************

DATE FOR THIS COMPUTER RUN : 12-02-2014
START TIME FOR THIS COMPUTER RUN : 14: 8:41: 1

APPENDIX C

GCCS DESIGN PLANS

ADS - ZION LANDFILL
SITE 2 EAST HORIZONTAL EXPANSION
UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS
Zion, Illinois
December 2014



LOCATION MAP

SHEET NO	TITLE
1	TITLE SHEET
2	EXISTING SITE CONDITIONS
3	PROPOSED GAS MANAGEMENT SYSTEM PLAN
4	LANDFILL GAS MANAGEMENT SYSTEM DETAILS
5	LANDFILL GAS MANAGEMENT SYSTEM DETAILS
6	LANDFILL GAS MANAGEMENT SYSTEM DETAILS

PREPARED FOR

Advanced Disposal

ZION LANDFILL
701 GREEN BAY ROAD
ZION, ILLINOIS 60099
(847) 599-5910

PREPARED BY

EIL
ENVIRONMENTAL INFORMATION LOGISTICS, LLC

534 DUANE STREET
GLEN ELLYN, IL 60137
(630) 942-0635

LEGEND

- N 13,000 — GRID COORDINATES
- APPROXIMATE FACILITY BOUNDARY
- EXPANSION WASTE AREA
- EXISTING PERMITTED LIMIT OF WASTE AREAS
- TREES / VEGETATION
- EXISTING FENCE
- PROPOSED FENCE
- EXISTING ACCESS ROAD
- EXISTING CULVERT
- EXISTING CONTOUR EXCEPT AS NOTED IN NOTE 1
- EXISTING TOPO CONTROL/ MONUMENT POINTS
- EXISTING LANDFILL GAS EXTRACTION WELL
- EXISTING CONTROL VALVE
- EXISTING CONDENSATE DRIPLEG
- S-6 NORTH TRENCH SUMP
- EXISTING GAS HEADER/LATERAL PIPE
- LEACHATE RECIRCULATION TRENCH
- LFG PIPING ABOVE COVER GEOMEMBRANE
- LEACHATE FORCEMAIN PIPE
- LEACHATE FORCEMAIN PIPING ABOVE COVER GEOMEMBRANE
- CONDENSATE DISCHARGE PIPE
- HORIZONTAL LFG WELL PIPE
- AIR SUPPLY PIPE
- AIR SUPPLY PIPE ABOVE COVER GEOMEMBRANE
- ELECTRICAL LINES
- CONDENSATE SUMP
- EW-40 GAS/LEACHATE EXTRACTION WELL
- REW-1 REMOTE EXTRACTION WELLHEAD
- NORTH TRENCH SUMP
- GAS MONITORING PROBE
- GROUNDWATER MONITORING WELL
- LEACHATE RECIRCULATION/LFG WELLHEAD
- LEACHATE CLEANOUT RISER
- APPROXIMATE GEOMEMBRANE COVER LIMITS

NOTES

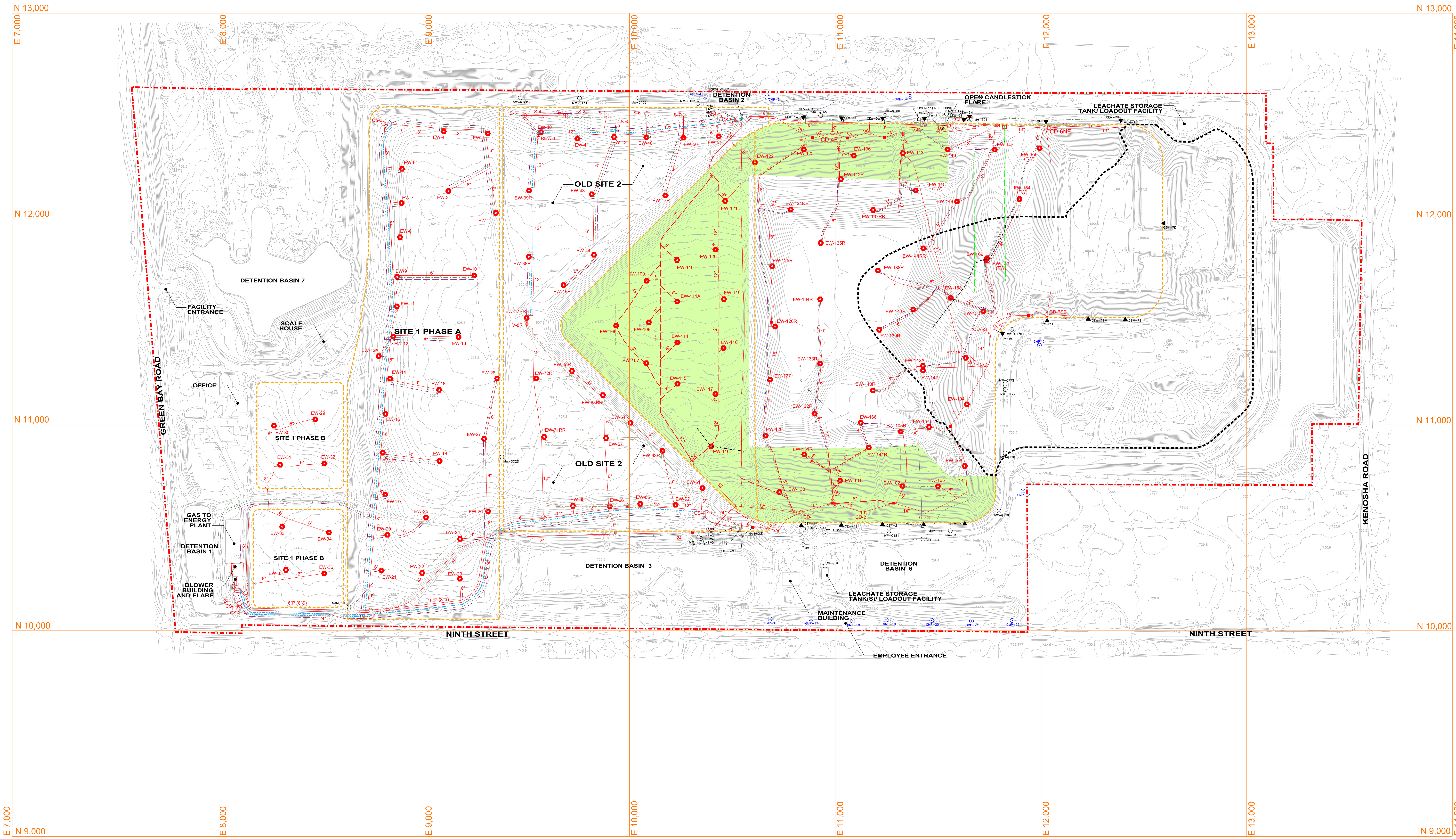
1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY AYRES ASSOCIATES ON APRIL 16, 2013 AND UPDATED WITH CQM, INC. SURVEYS DATED JULY 1, 2013. CONTOUR INTERVAL IS 2 FEET AND ELEVATIONS ARE U.S.G.S MEAN SEA LEVEL DATUM BY MARTINEZ CORPORATION.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. EXISTING GAS SYSTEM SHOWN TAKEN FROM DRAWING 1, ENTITLED "LANDFILL GAS AND LEACHATE SYSTEM PLAN", PROVIDED BY CQM, INC., DATED JANUARY 2014.

N

GRAPHIC SCALE

200 0 100 200 400 800

(IN FEET) 1 inch = 200 ft.



DRN	
DES	
CHK	
APP	
INITIAL	DATE

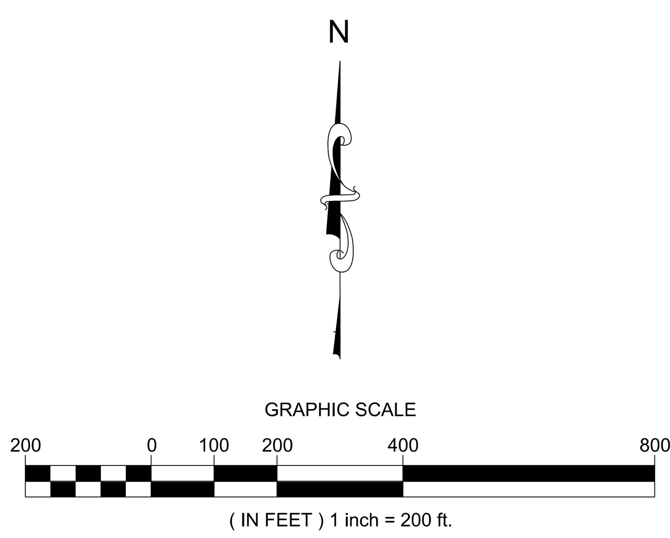
PREPARED FOR: Advanced Disposal

PREPARED BY: EIL ENVIRONMENTAL INFORMATION LOGISTICS, LLC

ADS - ZION LANDFILL
SITE 2 EAST HORIZONTAL EXPANSION
UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS
CITY OF ZION, ILLINOIS

EXISTING CONDITIONS PLAN

DATE	DECEMBER 2014
PROJECT NO	141007
FILE NAME	001 HE EX GCCS PLAN
SHEET NO	1 OF 6
DRAWING NO	1



LEGEND

N 13,000	GRID COORDINATES
	APPROXIMATE FACILITY BOUNDARY
	EXPANSION WASTE AREA
	EXISTING PERMITTED LIMIT OF WASTE AREAS
	TREES / VEGETATION
	EXISTING FENCE
	PROPOSED FENCE
	ACCESS ROAD (SEE NOTE 1 FOR EXISTING VS. PROPOSED)
	CULVERT (SEE NOTE 1 FOR EXISTING VS. PROPOSED)
760	PROPOSED CONTOUR: TOP OF FINAL LANDFORM (FEET MSL)
760	EXISTING CONTOUR EXCEPT AS NOTED IN NOTE 1
v1add Z 728.000	EXISTING TOPO CONTROL/ MONUMENT POINTS
S-6	NORTH TRENCH SUMP
	GAS HEADER/LATERAL PIPE
	GAS HEADER ON GRANULAR DRAINAGE LAYER
	CONDENSATE DRAIN/ DRIPLEG
	CONTROL VALVE
	LANDFILL GAS EXTRACTION WELL
	GAS HEADER ACCESS RISER
	GAS HEADER HIGH POINT
GMP-22	EXISTING LANDFILL GAS MONITORING PROBE
GMP-40	PROPOSED LANDFILL GAS MONITORING PROBE

NOTES

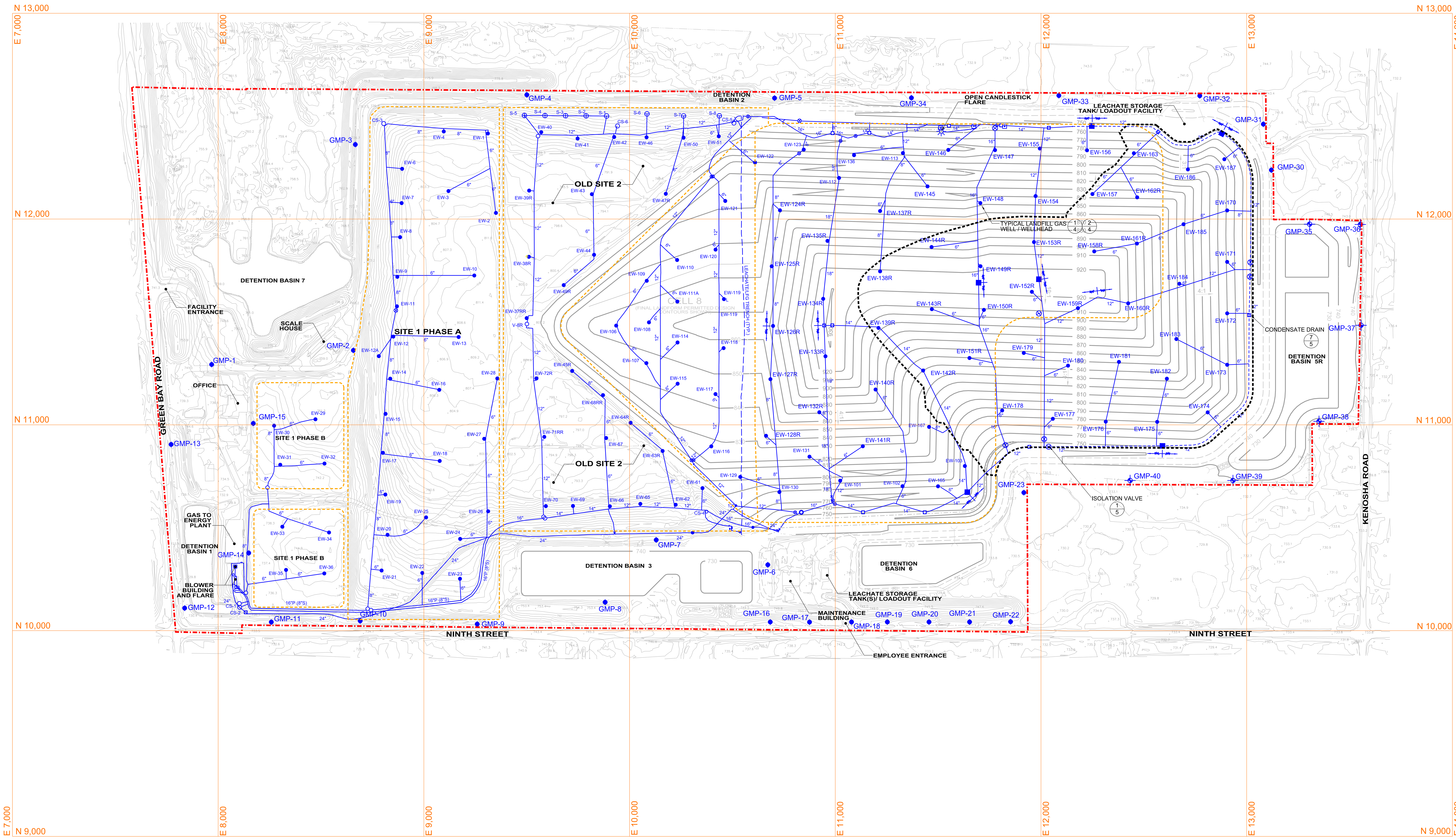
1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY AYRES ASSOCIATES ON APRIL 16, 2013 AND UPDATED WITH CQM, INC. SURVEYS DATED JULY 1, 2013. CONTOUR INTERVAL IS 2 FEET AND ELEVATIONS ARE U.S.G.S MEAN SEA LEVEL DATUM BY MARTINEZ CORPORATION.

   CELL 8 AREA: FINAL PERMITTED COVER DESIGN

   DETENTION BASIN 5R: PERMITTED CONTOURS

   DETENTION BASINS 3 AND 6: PERMITTED CONTOURS

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. LANDFILL GAS MONITORING PROBES WILL BE PHASED IN AROUND THE PERIMETER OF THE FILLED ACTIVE AREA. LOCATION OF LANDFILL GAS PROBES ARE APPROXIMATE.
4. PROPOSED LANDFILL GAS EXTRACTION WELLS WILL BE CONSTRUCTED AS FINAL CONTOURS ARE ATTAINED.
5. ALL PENETRATIONS THROUGH THE FINAL COVER GEOMEMBRANE WILL BE BOOTED.
6. PROPOSED PIPING SLOPE
   - MINIMUM 0.3% IF ON SOILS
   - MINIMUM 5% IF ON WASTE
7. LANDFILL GAS PIPING MAY BE INSTALLED ABOVE OR BELOW THE FINAL COVER GEOMEMBRANE.
8. NAMING CONVENTION OF WELLS IS SUBJECT TO CHANGE.
9. THE PROPOSED PLAN IS CONCEPTUAL AND REPRESENTS TYPICAL PROPOSED LFG WELL AND HEADER SYSTEM LAYOUT. LFG WELLS AND PIPE LOCATIONS ARE APPROXIMATE. LFG WELLS, CONDENSATE KNOCK-OUTS AND GAS COLLECTIONS PIPE LOCATIONS MAY BE ADJUSTED AND ADDITIONAL LFG WELLS AND PIPES MAY BE ADDED DURING AND AFTER WASTE FILLING OPERATIONS. AS-BUILTS WILL BE KEPT ON FILE AS REQUIRED.
10. EXISTING LFG WELLS INSTALLED PRIOR TO REACHING FINAL GRADE MAY EITHER BE EXTENDED TO THE FINAL GRADE LEVEL OR ABANDONED AND REDRILLED. THE DETERMINATION WILL BE MADE BASED UPON THE PHYSICAL CONDITION OF WELLS, REQUIRED ADDITIONAL WASTE THICKNESS TO REACH FINAL GRADE, WELLS ABILITY TO PROVIDE EFFECTIVE LFG EXTRACTION, AND FIELD CONDITIONS AT THE TIME OF FINAL COVER CONSTRUCTION. LATERAL CONNECTIONS TO THE RE-DRILLED LFG WELLS MAY BE ADJUSTED BASED ON FIELD CONDITIONS ENCOUNTERED AT THAT TIME. LOCATION AND INSTALLATION OF THE LATERAL ALIGNMENT MAY VARY TO ACCOMMODATE LANDFILL FIELD SLOPE.
11. THE PROPOSED PIPE SIZES INDICATED ON THIS DRAWING REPRESENTS MINIMUM PIPE SIZES. PIPE SIZES MAY BE INCREASED IF NECESSARY AND ADDITIONAL HEADER/LATERALS MAY BE ADDED FOR ADDITIONAL CROSSOVER AND RAISED LFG WELLS AS NEEDED IN THE FUTURE.
12. LOCATION AND INSTALLATION OF THE PROPOSED GAS SYSTEM AND LATERAL ALIGNMENT MAY VARY TO ACCOMMODATE LANDFILL FIELD SLOPE.
13. EXISTING GAS SYSTEM SHOWN TAKEN FROM DRAWING 1, ENTITLED "LANDFILL GAS AND LEACHATE SYSTEM PLAN", PROVIDED BY CQM, INC., DATED JANUARY 2014.



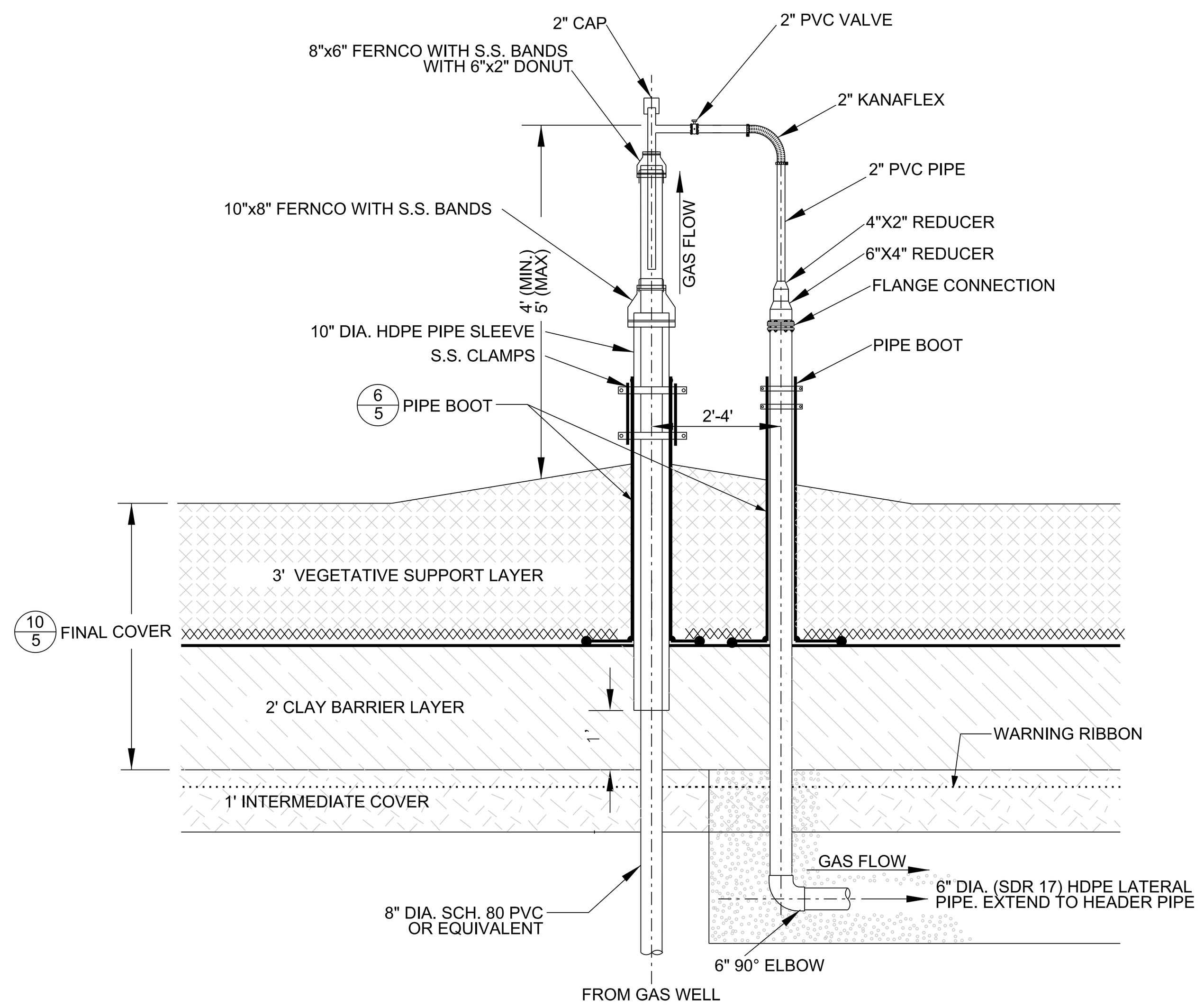
PREPARED FOR

PREPARED BY

ADS - ZION LANDFILL
SITE 2 EAST HORIZONTAL EXPANSION
UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS
CITY OF ZION, ILLINOIS

PROPOSED GAS MANAGEMENT SYSTEM PLAN

DATE	DECEMBER 2014
PROJECT NO	141007
FILE NAME	017 HE PROP GAS PLAN
SHEET NO	2 OF 6
DRAWING NO	2

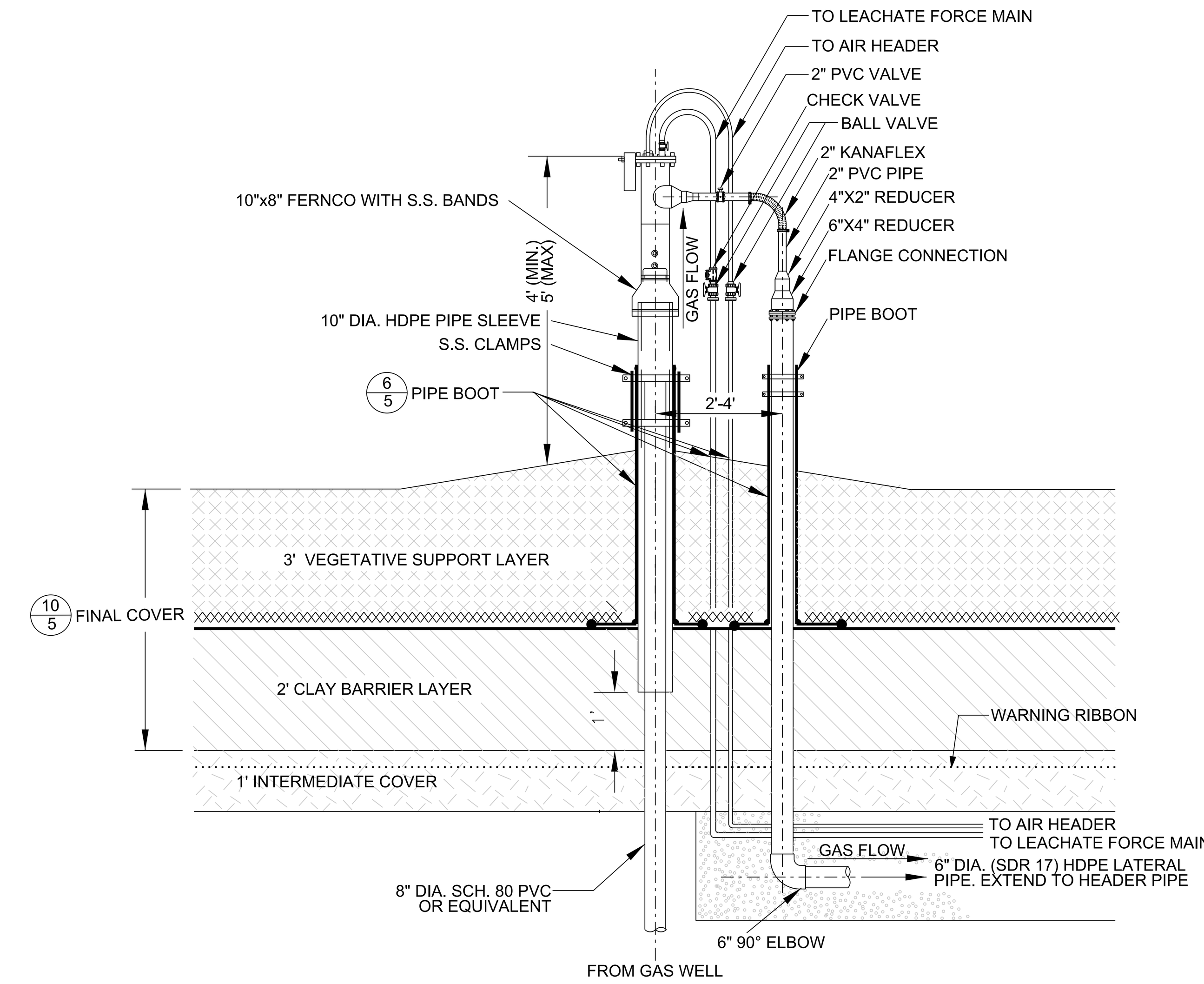


GAS EXTRACTION WELL AND LATERAL 1/4

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

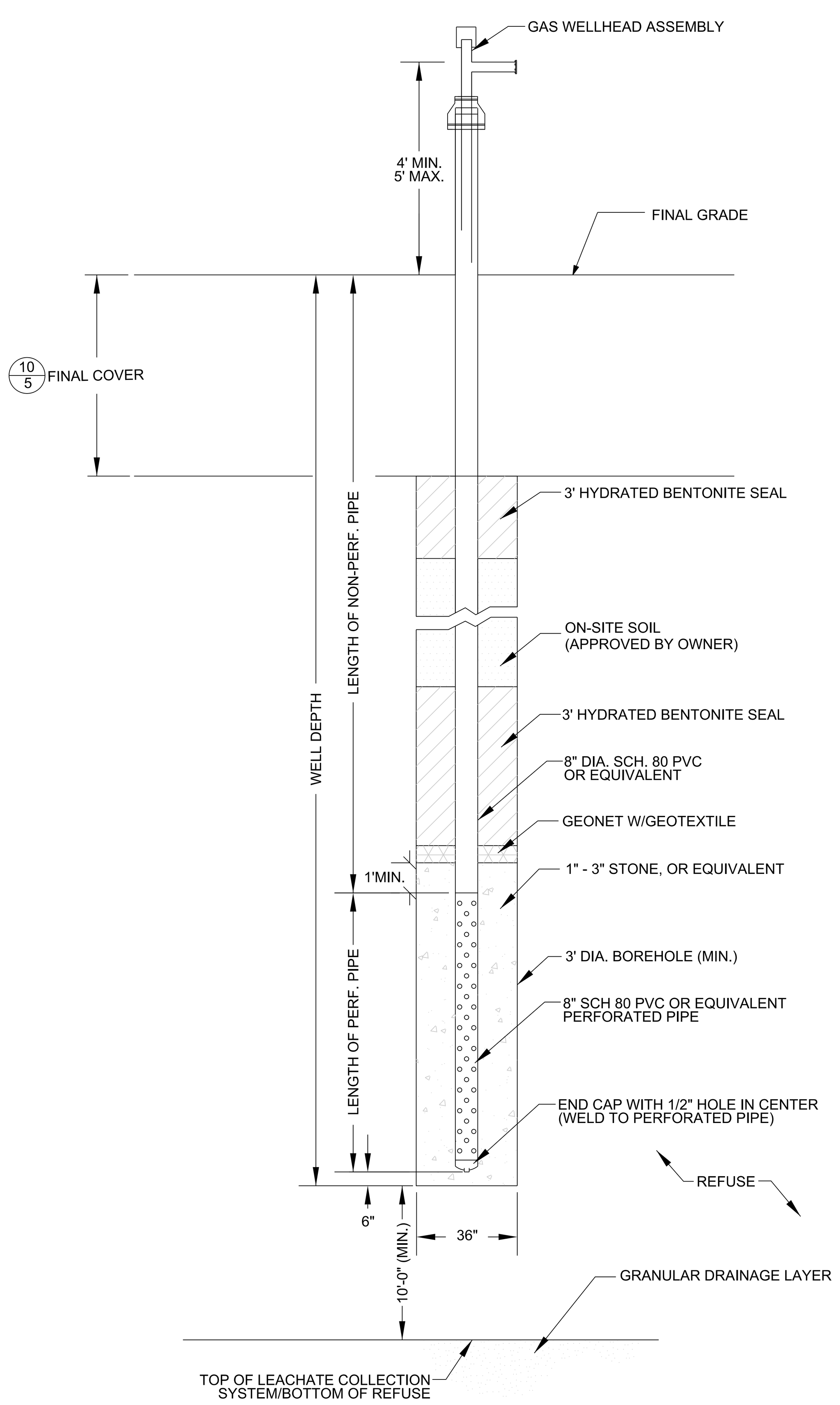


GAS/LEACHATE EXTRACTION WELL AND LATERAL 3/4

NOT TO SCALE

NOTE:

1. LEACHATE EXTRACTION INFRASTRUCTURE TO BE INSTALLED AS NEEDED.
2. ALL PIPE DIAMETERS ARE MINIMUMS.

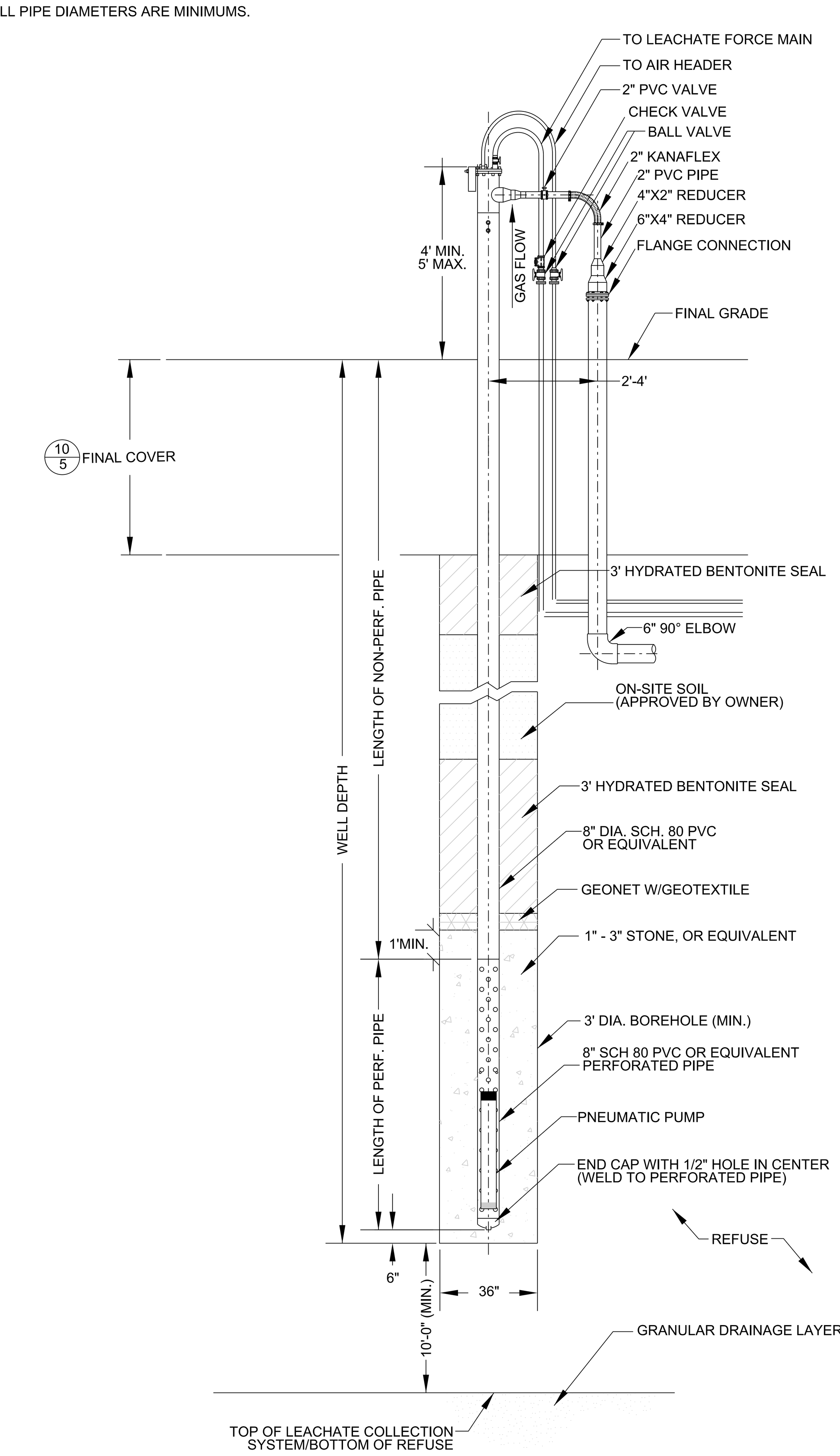


GAS EXTRACTION WELL 2/4

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.



GAS/LEACHATE EXTRACTION WELL 4/4

NOT TO SCALE

NOTE:

1. LEACHATE EXTRACTION INFRASTRUCTURE TO BE INSTALLED AS NEEDED.
2. ALL PIPE DIAMETERS ARE MINIMUMS.

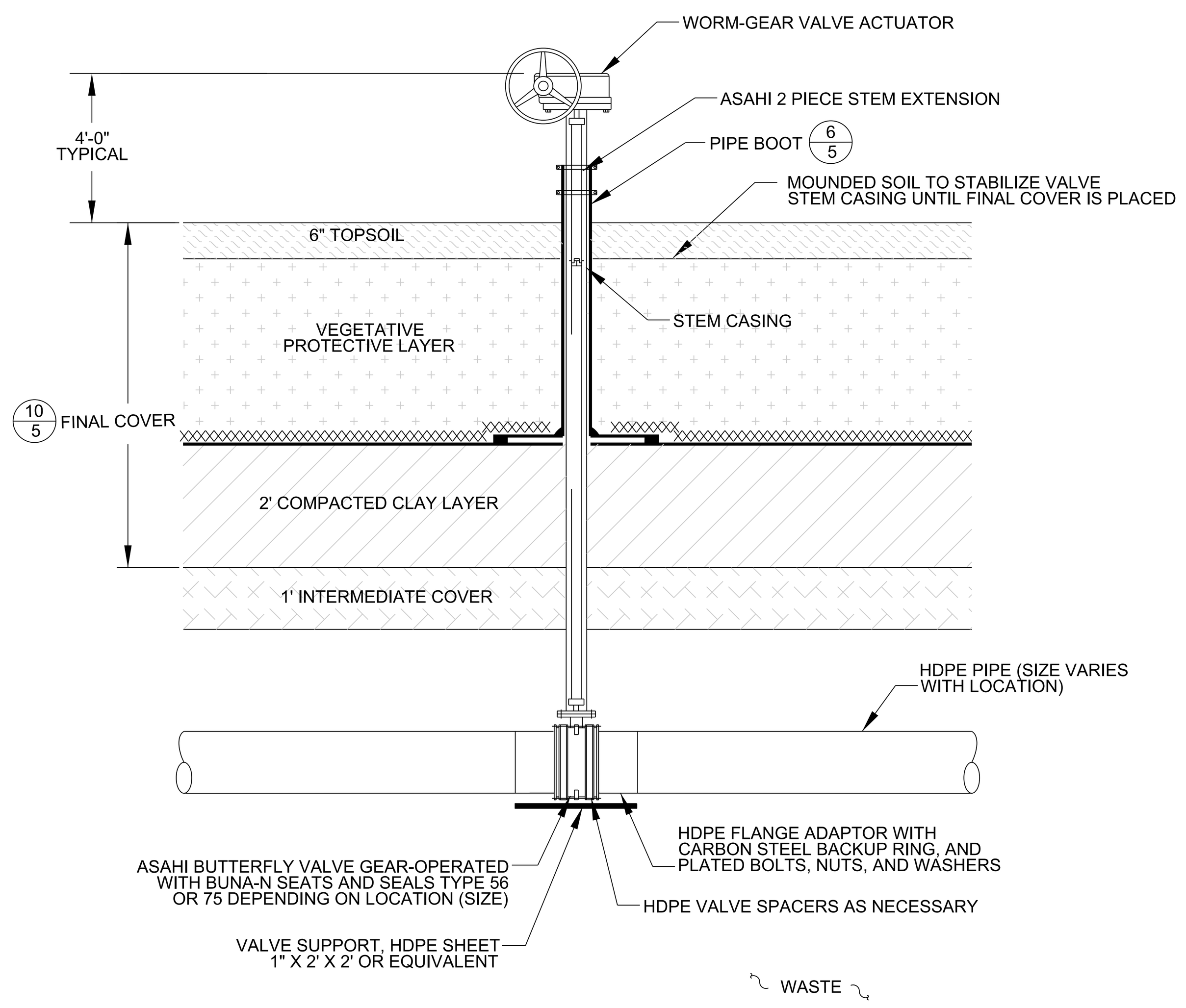
PREPARED FOR: Advanced Disposal

PREPARED BY: EIL ENVIRONMENTAL INFORMATION LOGISTICS, LLC

ADS - ZION LANDFILL
SITE 2 EAST HORIZONTAL EXPANSION
UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS
CITY OF ZION, ILLINOIS

LANDFILL GAS MANAGEMENT SYSTEM DETAILS

DATE	DECEMBER 2014
PROJECT NO	141007
FILE NAME	DETAIL 1
SHEET NO	4 OF 6
DRAWING NO	4

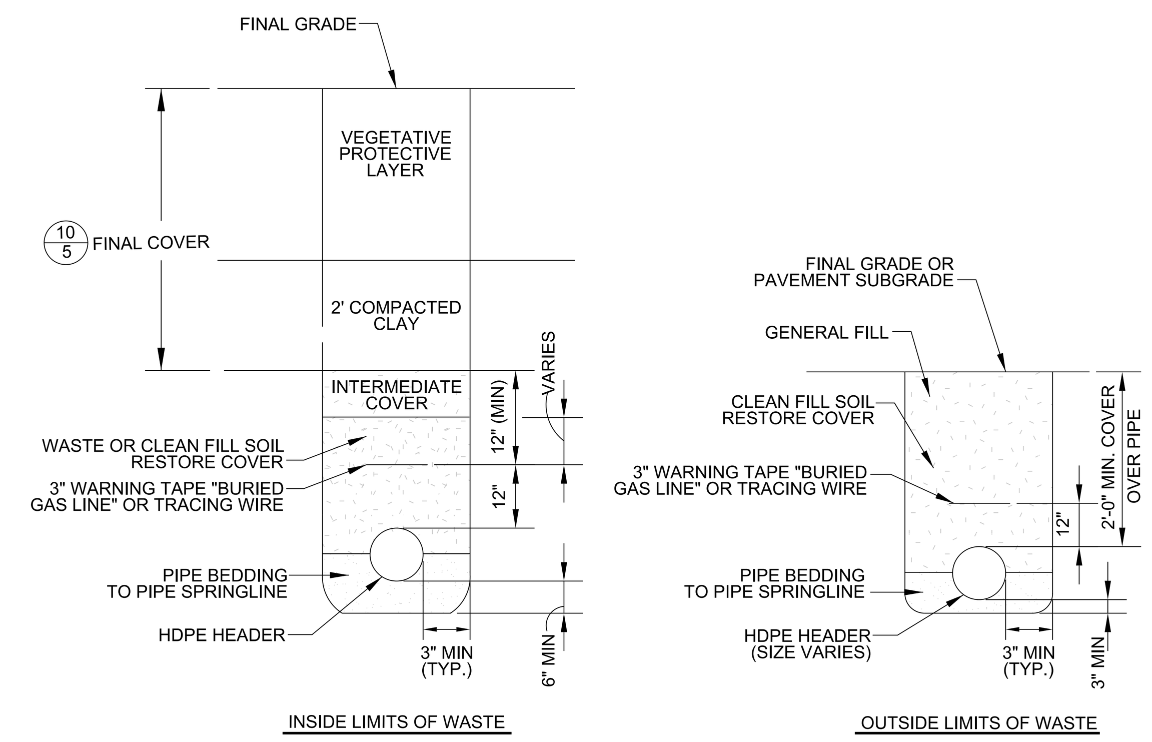


UNDERGROUND CONTROL VALVE 1/5

NOT TO SCALE

NOTES:

1. GAS PIPING MAY BE INSTALLED ABOVE OR BELOW THE FINAL COVER GEOMEMBRANE.
2. ALL PIPE DIAMETERS ARE MINIMUMS.

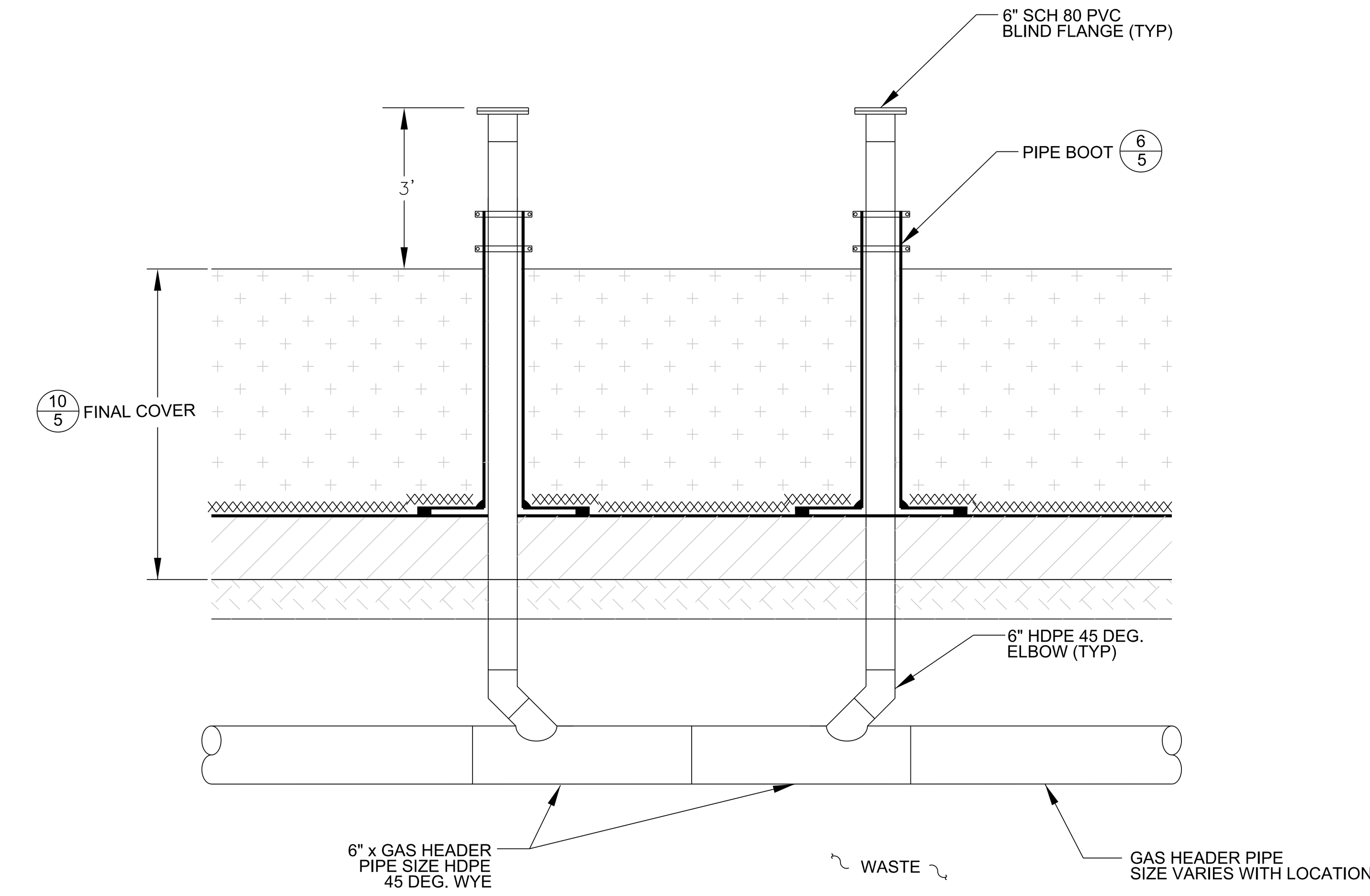


GAS HEADER TRENCH 2/5

NOT TO SCALE

NOTES:

1. COMPACT BACKFILL.
2. VIEW INSIDE LIMITS OF WASTE ASSUMES PIPING WILL BE INSTALLED PRIOR TO 40 MIL. GEOMEMBRANE. HOWEVER, IN SOME CASES HDPE HEADER PIPE MAY BE INSTALLED ABOVE 40 MIL. GEOMEMBRANE DEPENDING ON FINAL COVER CONSTRUCTION PHASING.
3. ALL PIPE DIAMETERS ARE MINIMUMS.

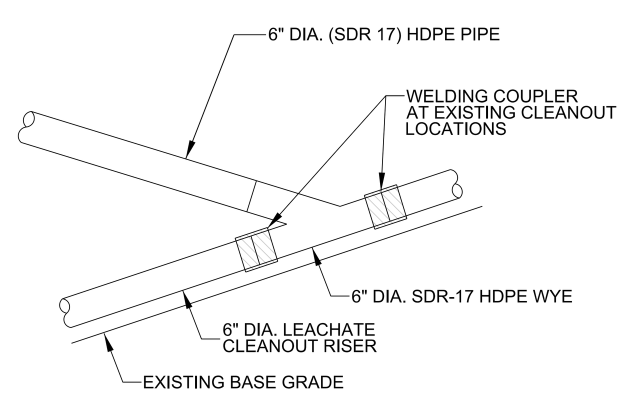


GAS HEADER ACCESS RISER 3/5

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

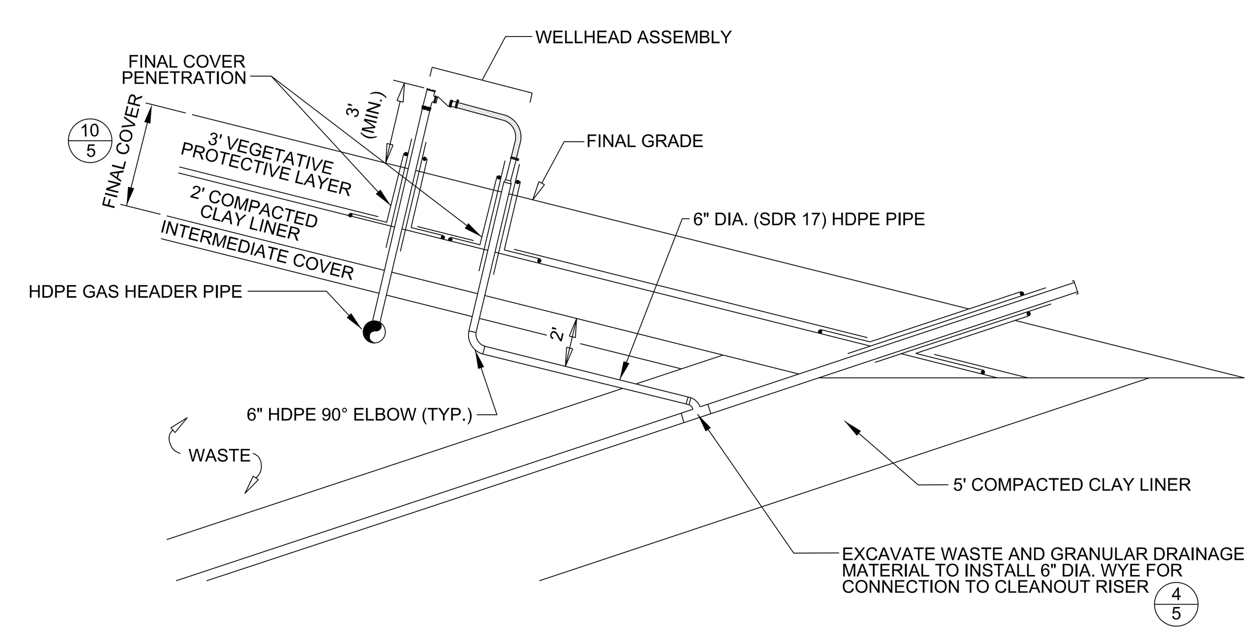


CLEANOUT CONNECTION 4/5

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

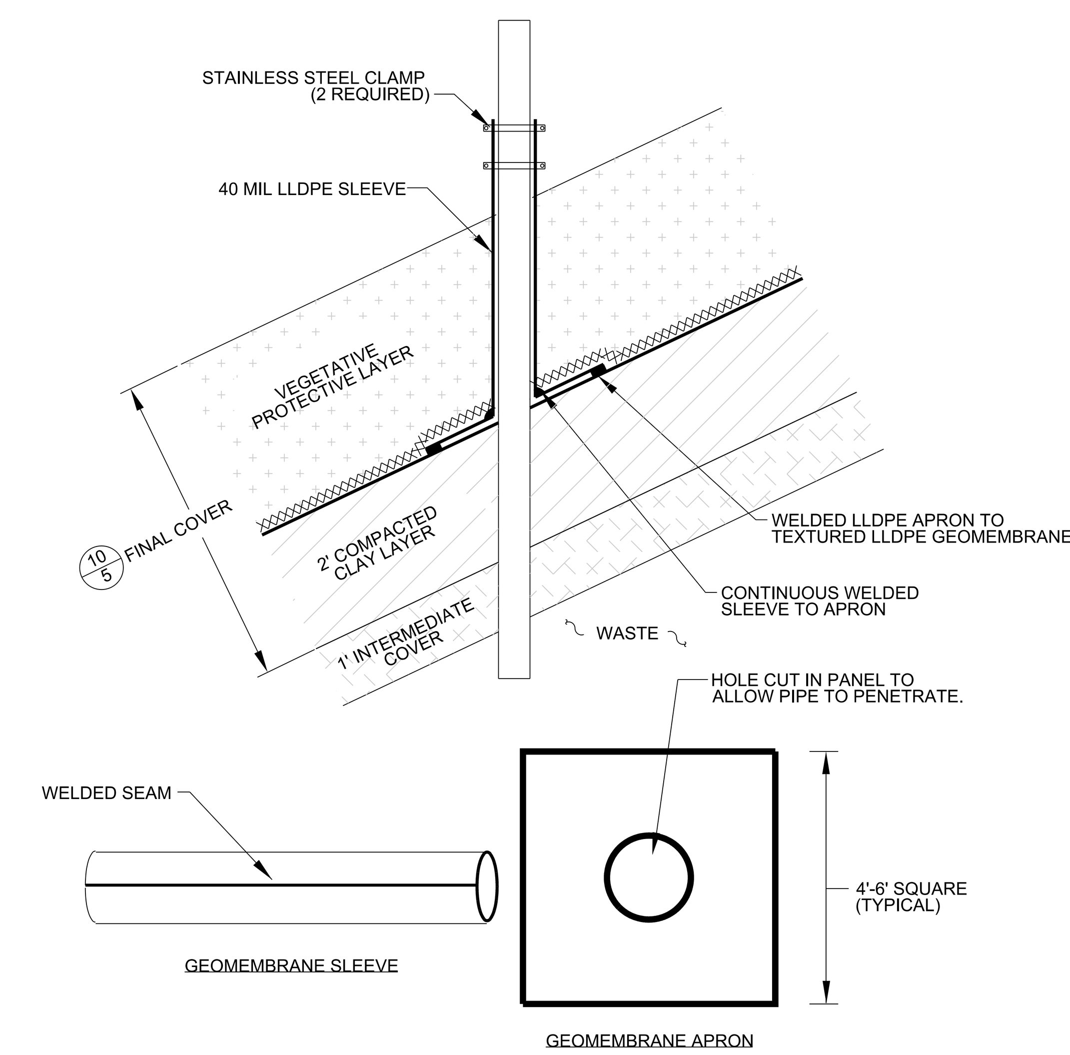


GAS EXTRACTION TIE-IN TO LEACHATE RISER 5/5

NOT TO SCALE

NOTE:

1. IF GAS PIPE IS PLACED IN VEGETATIVE SUPPORT LAYER, THEN FINAL COVER PENETRATION IS NOT REQUIRED.
2. ALL PIPE DIAMETERS ARE MINIMUMS.

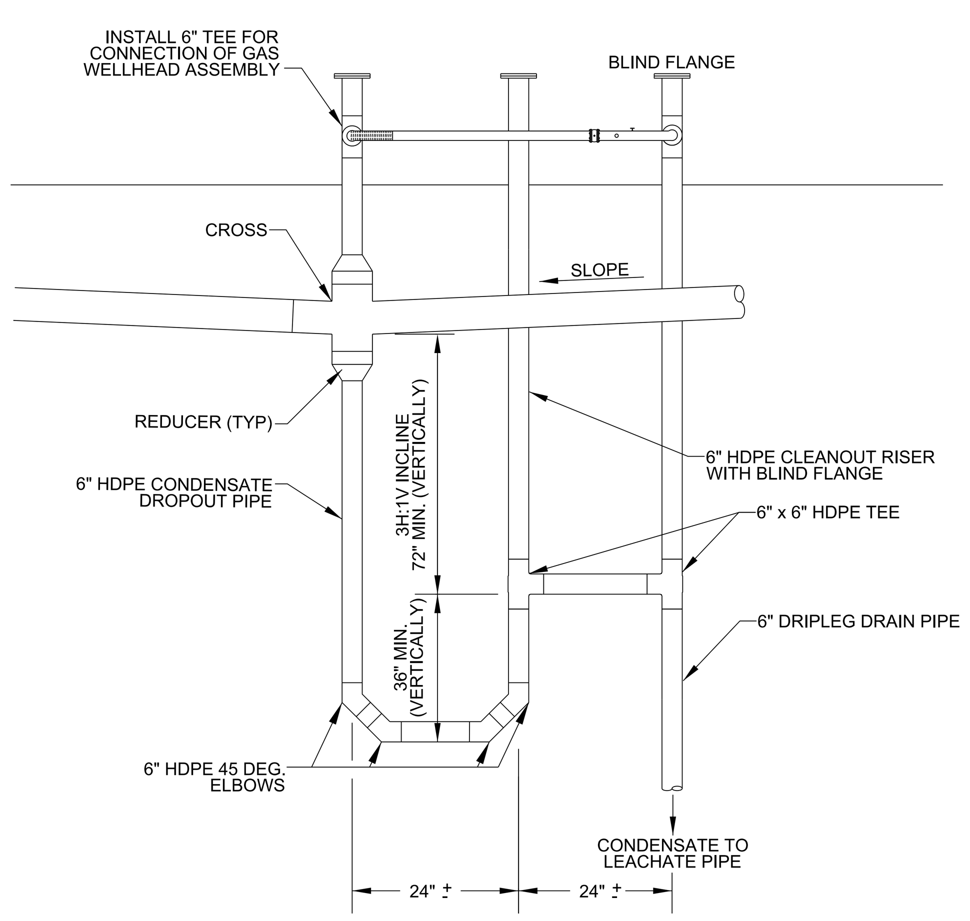


VERTICAL PENETRATION/PIPE BOOT (TYP.) 6/5

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

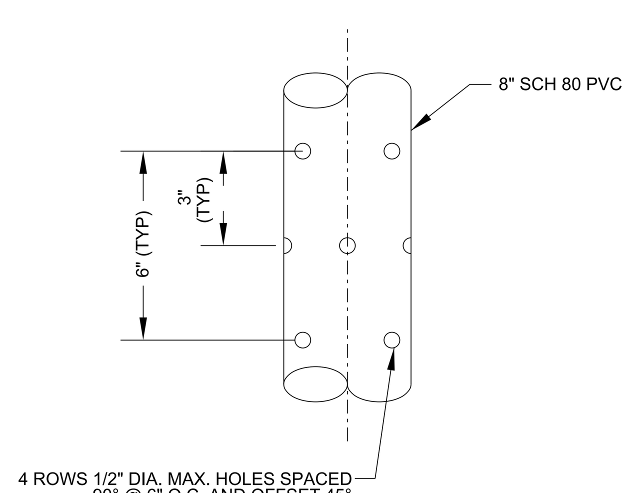


TYPICAL INCLINED CONDENSATE DRAIN 7/5

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

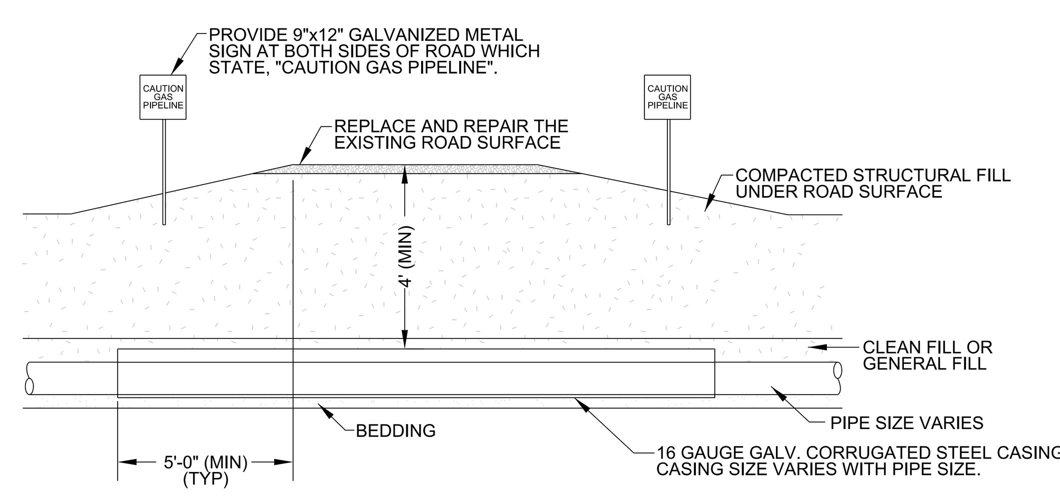


PERFORATED WELL PIPE 8/5

NOT TO SCALE

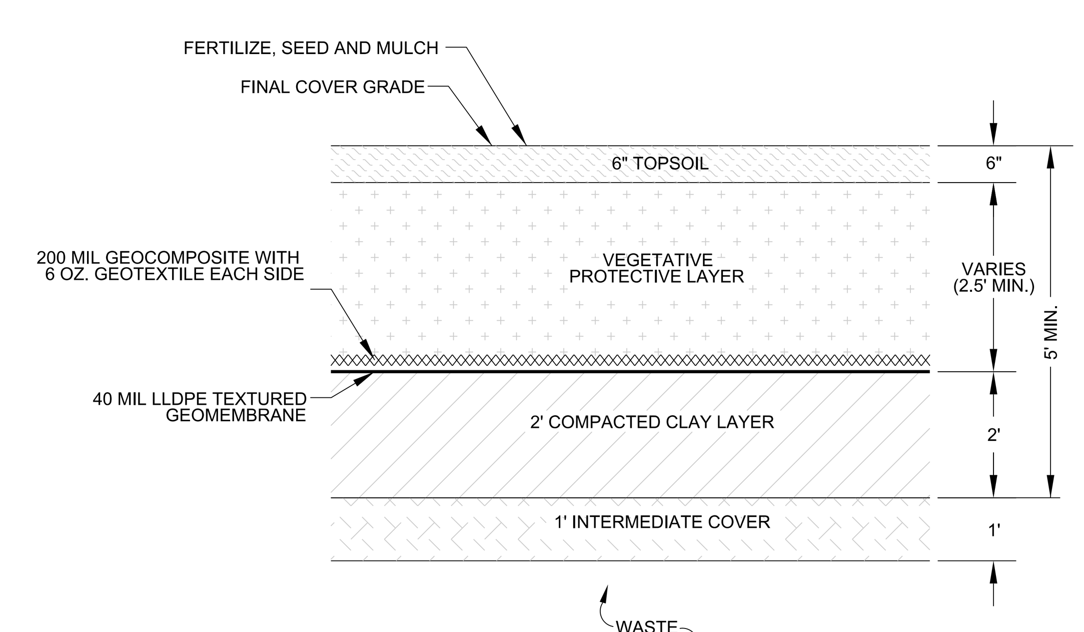
NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.



TRENCHED ROAD CROSSING 9/5

NOT TO SCALE



FINAL COVER 10/5

NOT TO SCALE

PREPARED FOR: Advanced Disposal

PREPARED BY: EIL ENVIRONMENTAL INFORMATION LOGISTICS, LLC

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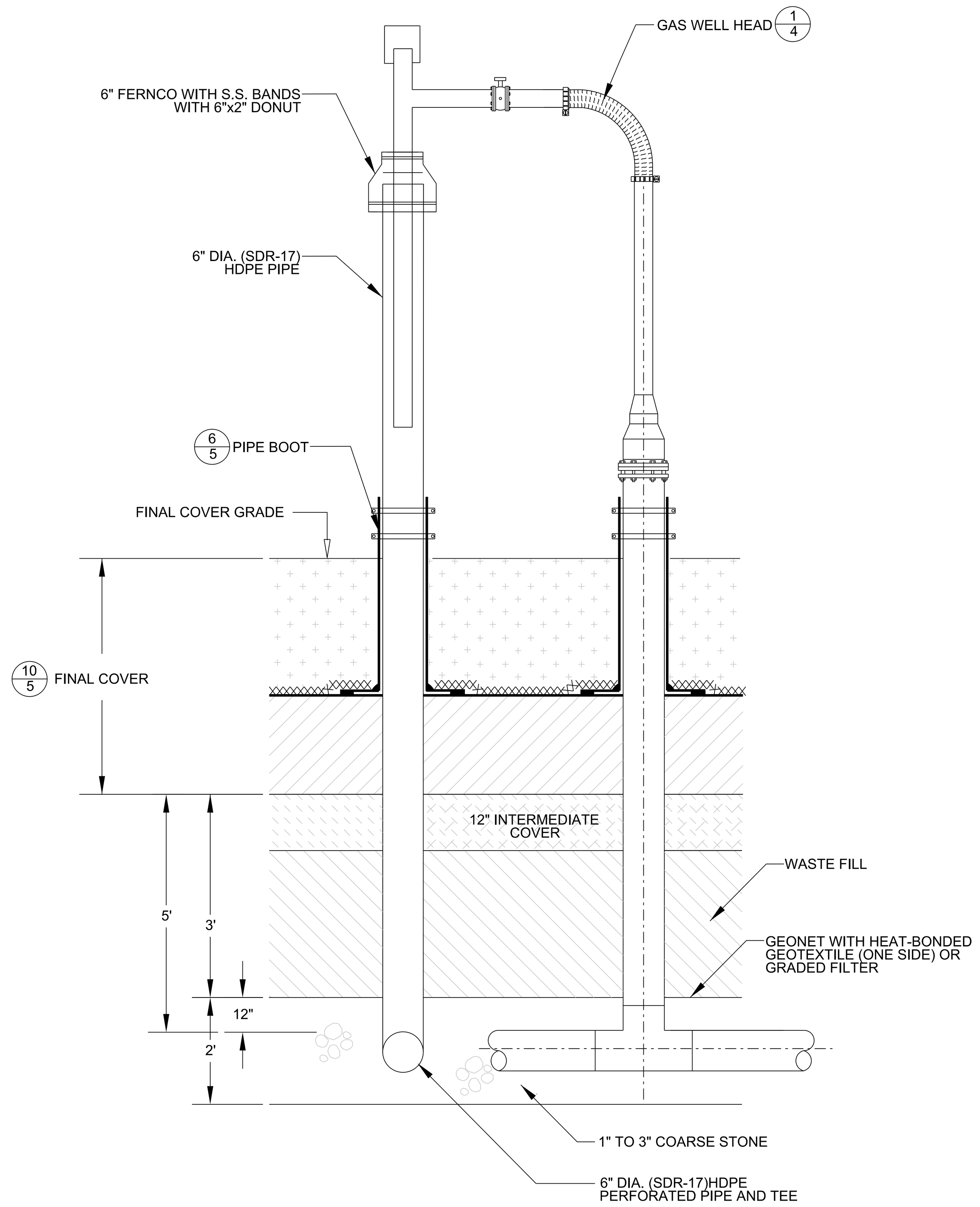
SITE 2 EAST HORIZONTAL EXPANSION
UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS
CITY OF ZION, ILLINOIS

LANDFILL GAS MANAGEMENT SYSTEM DETAILS

DATE	DECEMBER 2014
PROJECT NO	141007
FILE NAME	DETAIL 5
SHEET NO	5 OF 6
DRAWING NO	5

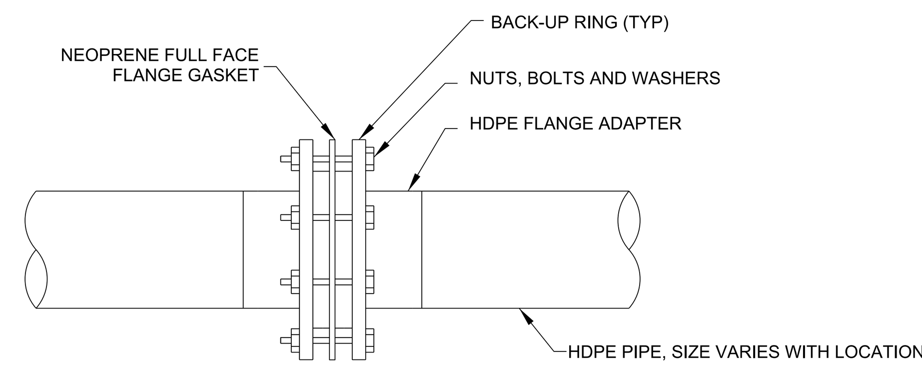


HORIZONTAL GAS COLLECTION TRENCH 1/6

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

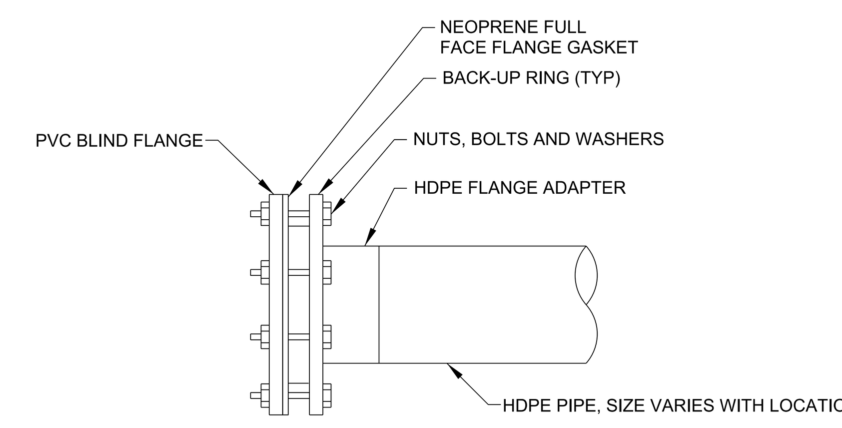


FLANGE CONNECTION (TYPICAL) 2/6

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

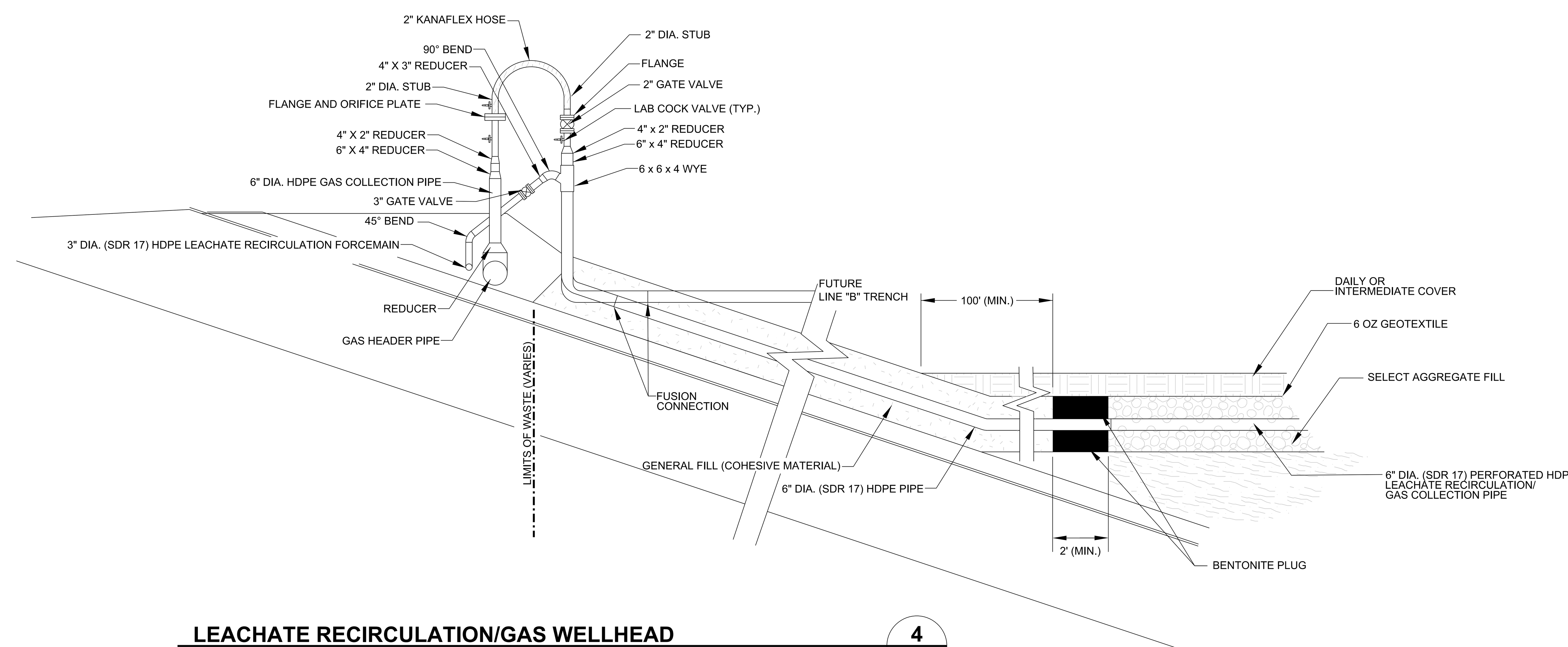


BLIND FLANGE CONNECTION (TYPICAL) 3/6

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

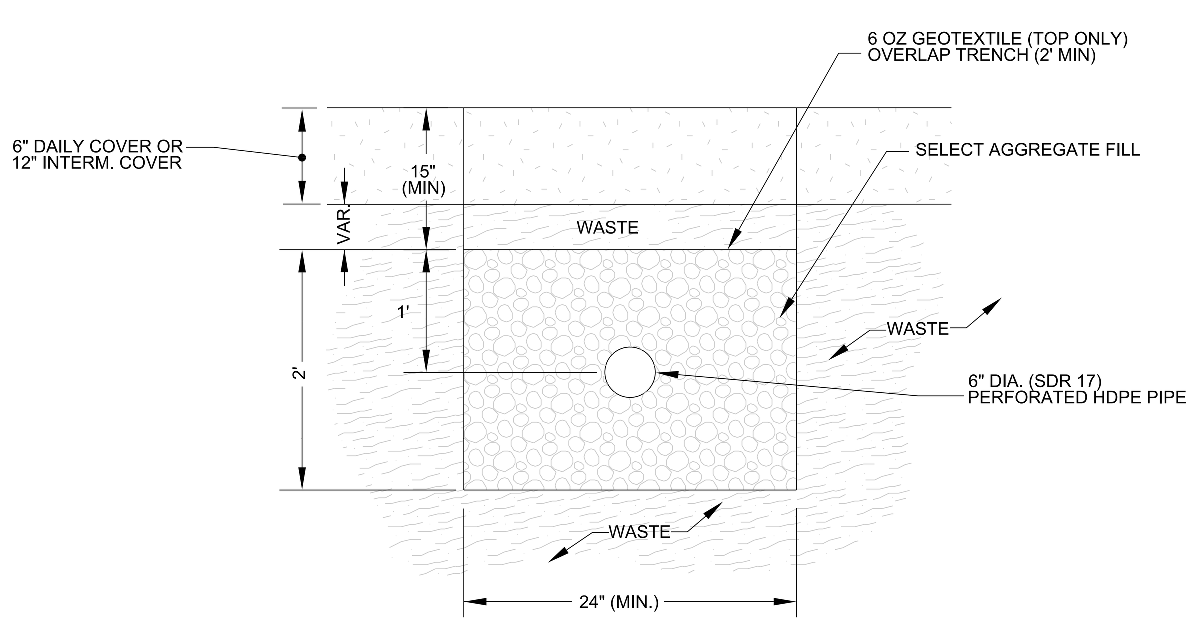


LEACHATE RECIRCULATION/GAS WELLHEAD 4/6

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

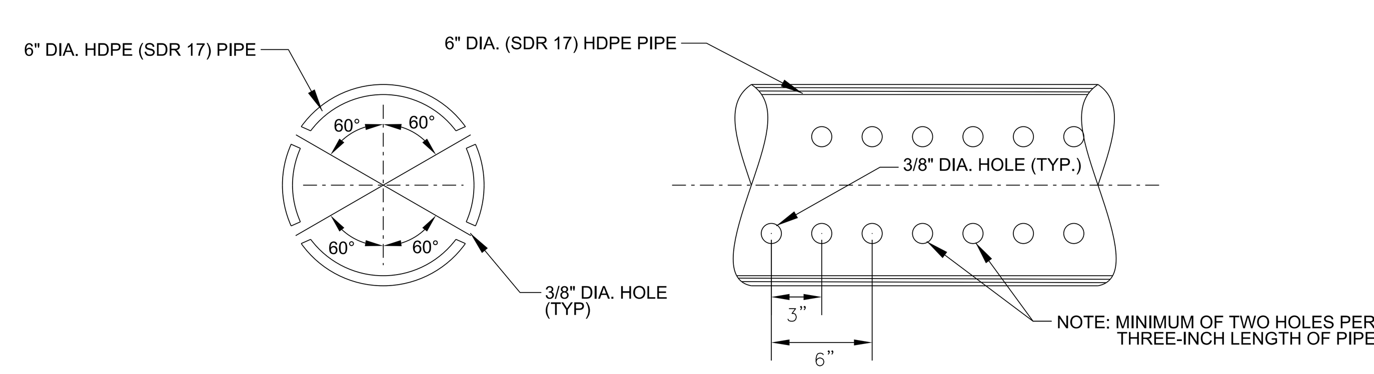


LEACHATE RECIRCULATION PIPE TRENCH 5/6

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.



PERFORATED HDPE LEACHATE RECIRCULATION/GAS COLLECTION PIPE 6/6

NOT TO SCALE

NOTE:

1. ALL PIPE DIAMETERS ARE MINIMUMS.

DRN			
DES			
CHK			
APP			
	INITIAL	DATE	

PREPARED FOR

Advanced Disposal

PREPARED BY

EIL ENVIRONMENTAL INFORMATION LOGISTICS, LLC

ADS - ZION LANDFILL
SITE 2 EAST HORIZONTAL EXPANSION
UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS
CITY OF ZION, ILLINOIS

LANDFILL GAS MANAGEMENT SYSTEM DETAILS

DATE	DECEMBER 2014
PROJECT NO	141007
FILE NAME	DETAIL 6
SHEET NO	6 OF 6
DRAWING NO	6

Appendix D

APPENDIX D

SURFACE EMISSIONS MONITORING PLAN

INTRODUCTION

40 CFR 60.755(c) requires the landfill gas collection system be operated so that the methane concentration is less than 500 ppm above background at the surface of the landfill. In addition, those areas that indicate elevated concentrations of LFG by visual observation (i.e., cracks or seeps in the landfill's cover and distressed vegetation) must also be monitored. This Surface Monitoring Design Plan specifies the monitoring procedures that will be used to meet the NSPS requirement. This plan includes topographical maps with the monitoring routes and specifies the monitoring procedures that will be followed. Any deviations from the surface monitoring requirements as stated in the NSPS are contained in this plan.

Areas Monitored

The NSPS requires monitoring along the entire perimeter of the collection area and along a serpentine pattern spaced 30 meters apart (or a site-specific established spacing) for each collection area on a quarterly basis. The attached map shows the surface monitoring route proposed for the facility at final grade conditions. The actual route taken while the facility is still active will be included with each quarterly surface scan report, or in other site files.

Areas which will be excluded include:

- Active areas of the site. Active areas are those areas which only have daily cover, and/or are being filled with waste. Active areas of the landfill have a larger volume of equipment and/or refuse trucks which pose an unacceptable health and safety risk to an individual in the area.
- Areas of the site with snow or ice cover. Snow has the potential to cover uneven surfaces in the landfill cover (such as ruts) which could cause the technician to twist or break a leg. Icy slopes are difficult and dangerous to traverse.
- Areas of the landfill with slopes equal to or greater than 4:1 (horizontal to vertical). These slopes present a safety hazard to the monitoring technician traversing them.
- Areas of the site that are undergoing construction or final cover activities. These areas also have a large volume of equipment traffic, which poses a health and safety risk to the technician performing the scan.
- Areas that have membrane liner only in place – limit foot traffic on FML due to slip/fall hazard.

Monitoring Frequency

Surface monitoring will be performed on a calendar quarter basis. Monitoring will be rescheduled if it cannot be conducted because temperature conditions are outside the operating range of the instrument and/or other conditions (snow cover, rain storms, etc.) prevent monitoring. The monitoring event will be rescheduled as soon as practical after the original scheduled date.

Surface Monitoring Instrument

The monitoring will be conducted with an organic vapor analyzer, flame ionization detector, or other portable monitor meeting the specifications in 40 CFR 60.755(d):

> “The portable analyzer shall meet the instrument specifications provided in section 3 of Method 21 of Appendix A of 40 CFR Part 60 (Method 21), except that "methane" shall replace all references to VOC.”

To meet the performance evaluation requirements in section 3.1.3 of Method 21, the instrument evaluation procedures of section 4.4 of Method 21 shall be used. The performance evaluation results will be documented in an instrument logbook or on a form similar to the one shown in Table A-1.

Surface Monitoring Survey

Immediately before commencing a surface monitoring survey, the instrument shall be calibrated per section 4.2 of Method 21. The calibration gas shall be methane, diluted to a nominal concentration of 500 parts per million in air. Calibrations will be documented in an instrument logbook or on a form similar to the one shown in Table A-2.

The background concentration at the facility will be determined immediately prior to conducting the survey. The background concentration shall be determined by moving the probe inlet upwind outside the boundary of the landfill at least 30 meters from the perimeter wells. The background concentration, measurement location, and basic meteorological conditions will be recorded on Table A-2 (or similar form). Other factors that can affect “background” should be noted and accounted for (such as a nearby landfill, highway, refinery, chemical plant, etc.).

Surface emission monitoring shall be performed in accordance with section 4.3.1 of Method 21, except that the probe inlet shall be placed within 5 to 10 centimeters of the ground and the probe will be moved continuously along the ground. Monitoring will not be performed during extreme meteorological conditions.

Surface monitoring will be conducted around the perimeter of the collection area and the route shown on the topographic map. Areas where visual observations indicate elevated concentrations of landfill gas, such as distressed vegetation and cracks or seeps in the cover, will be monitored.

Any reading of 500 parts per million or more above background at any location shall be recorded as a monitored exceedance and the following actions shall be taken:

i. The location of each monitored exceedance shall be marked and the location recorded. A typical form for documenting monitoring exceedances is included in this plan. Other forms for tracking exceedances may be utilized.

ii. Cover maintenance or adjustments to the vacuum of the adjacent wells to increase the gas collection in the vicinity of each exceedance shall be made and the location shall be re-monitored within 10 calendar days of detecting the exceedance.

iii. If the re-monitoring of the location shows a second exceedance, additional corrective action shall be taken and the location shall be monitored again within 10 days of the second exceedance. If the re-monitoring shows a third exceedance for the same location, the action specified in paragraph (v) below shall be taken, and no further monitoring of that location is required until the action specified in paragraph (v) has been taken.

iv. Any location that initially showed an exceedance but has a methane concentration less than 500 ppm methane above background at the 10-day re-monitoring specified in paragraph (c)(4) (ii) or (iii) of this section shall be re-monitored 1 month from the initial exceedance. If the 1-month remonitoring shows a concentration less than 500 parts per million above background, no further monitoring of that location is required until the next quarterly monitoring period. If the 1-month remonitoring shows an exceedance, the actions specified in paragraph (iii) or (v) shall be taken.

v. For any location where monitored methane concentration equals or exceeds 500 parts per million above background three consecutive times within a quarterly period, a new well or other collection device shall be installed within 120 calendar days of the initial exceedance. An alternative remedy to the exceedance, such as upgrading the blower, header pipes or control device, and a corresponding timeline for installation may be submitted to the Administrator for approval.

Reduced Monitoring Frequency for Closed Landfills

Any closed landfill that has no monitored exceedances of the 500 ppm limit above background in three consecutive quarterly monitoring periods may skip to annual monitoring. Any methane reading of 500 ppm or more above background detected during the annual monitoring returns the frequency to quarterly monitoring. The facility will go to an annual schedule for areas of the site that are at final grade, and certified as closed, once three consecutive quarters with no surface monitoring exceedances have been performed. This alternative monitoring schedule was approved by Region 4 USEPA on July 12, 2004 for an NSPS landfill in Georgia (Applicability Determination Index Control No. 0500087). Currently, the final closed areas are located in Phase 1a, Phase b, “old” Site 2 and sections of the Site 2 Expansion area.

LEGEND

- N 13,000 — GRID COORDINATES
- APPROXIMATE FACILITY BOUNDARY
- EXPANSION WASTE AREA
- EXISTING PERMITTED LIMIT OF WASTE AREAS
- TREES / VEGETATION
- EXISTING FENCE
- PROPOSED FENCE
- ACCESS ROAD (SEE NOTE 1 FOR EXISTING VS. PROPOSED)
- CULVERT (SEE NOTE 1 FOR EXISTING VS. PROPOSED)
- PROPOSED CONTOUR: TOP OF FINAL LANDFORM (FEET MSL)
- EXISTING CONTOUR EXCEPT AS NOTED IN NOTE 1
- EXISTING TOPO CONTROL/ MONUMENT POINTS
- NORTH TRENCH SUMP
- GAS HEADER/LATERAL PIPE
- GAS HEADER ON GRANULAR DRAINAGE LAYER
- CONDENSATE DRAIN
- CONTROL VALVE
- EW-152 — LANDFILL GAS EXTRACTION WELL
- GAS HEADER ACCESS RISER
- GAS HEADER HIGH POINT
- SURFACE SCAN ROUTE

NOTES

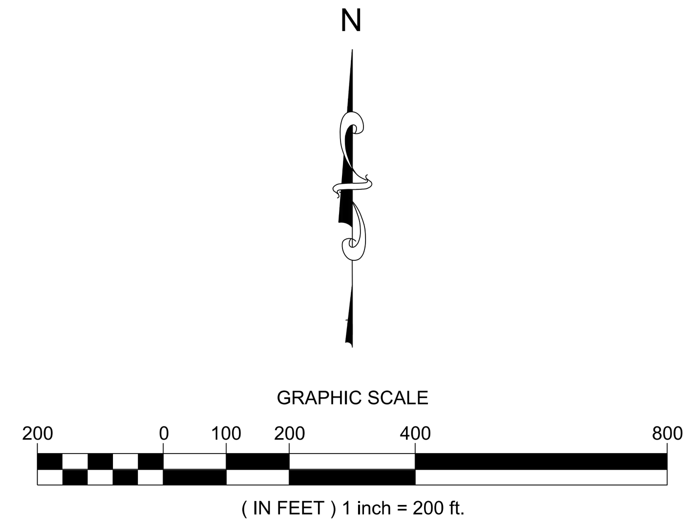
1. EXISTING CONTOURS DEVELOPED FROM SITE AERIAL TOPOGRAPHIC SURVEY BY AYRES ASSOCIATES ON APRIL 16, 2013 AND UPDATED WITH CQM, INC. SURVEYS DATED JULY 1, 2013. CONTOUR INTERVAL IS 2 FEET AND ELEVATIONS ARE U.S.G.S MEAN SEA LEVEL DATUM BY MARTINEZ CORPORATION.

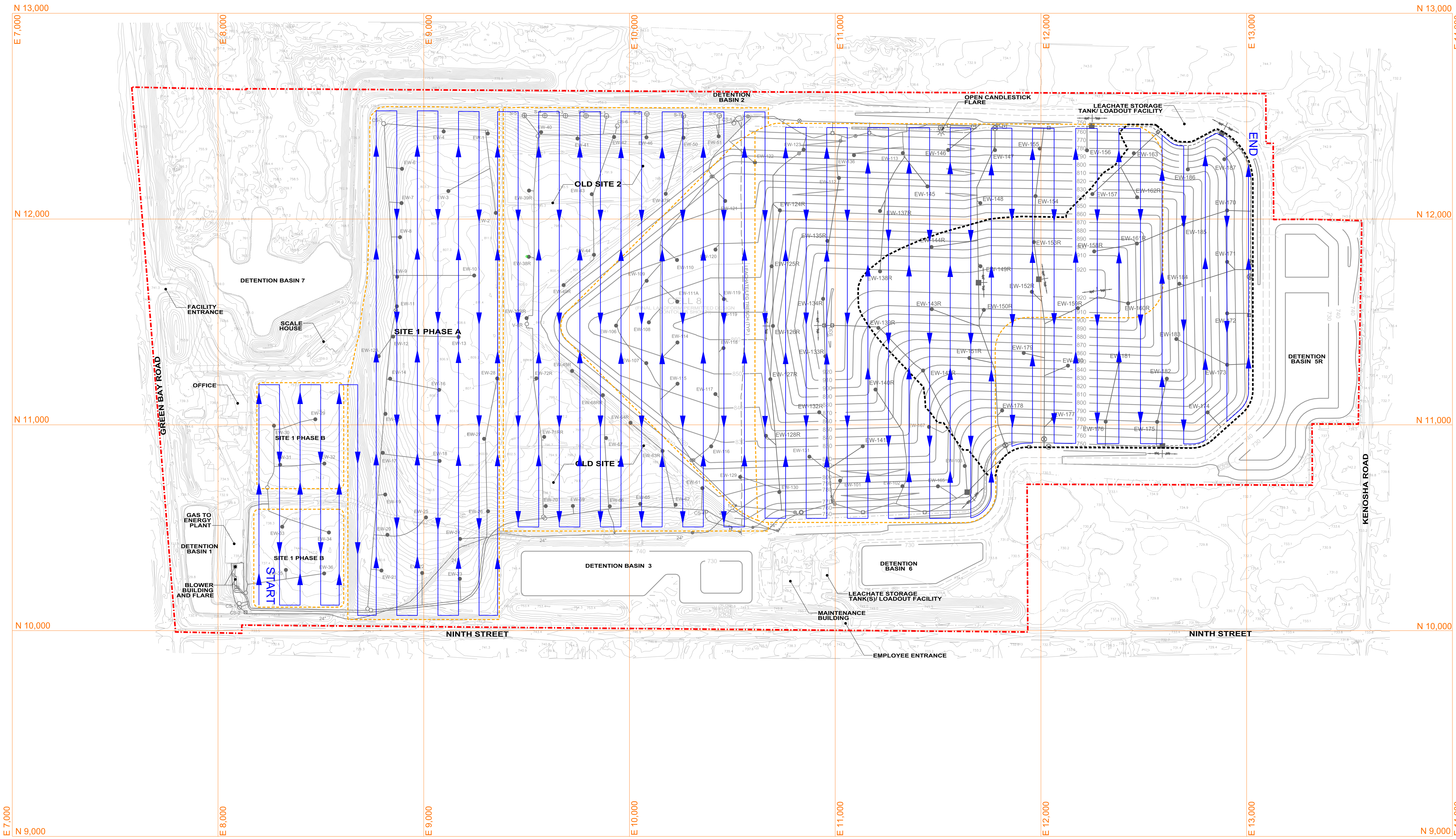
   CELL 8 AREA: FINAL PERMITTED COVER DESIGN

   DETENTION BASIN 5R: PERMITTED CONTOURS

   DETENTION BASINS 3 AND 6: PERMITTED CONTOURS

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. THIS SURFACE MONITORING DESIGN PLAN REPRESENTS THE LANDFILL AT FINAL CLOSURE CONDITIONS. SURFACE MONITORING CONDUCTED WHILE THE SITE IS STILL ACTIVE MAY FOLLOW A DIFFERENT ROUTE.





PREPARED FOR	Advanced Disposal
PREPARED BY	EIL ENVIRONMENTAL INFORMATION LOGISTICS, LLC
	ADS - ZION LANDFILL SITE 2 EAST HORIZONTAL EXPANSION UPDATED GAS COLLECTION AND CONTROL SYSTEM PLANS CITY OF ZION, ILLINOIS
	SURFACE SCAN PLAN
DATE	DECEMBER 2014
PROJECT NO	141007
FILE NAME	ZION PROP GCCS SC PLAN
SHEET NO	1 OF 1
DRAWING NO	1

Table A - 1
Monitoring Instrument Performance Evaluation
Surface Monitoring Design Plan

40 CFR 60.755(d)(3) requires performance evaluation of response factor, response time and calibration precision according to the section 4.4 of 40 CFR 60 Appendix A, Method 21. The requirements are presented below along with locations to record the evaluations.

Response Factor:
Response factor is the ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation. Since the monitoring instrument is being used to detect methane and the calibration reference compound is methane, the response factor by definition is one. No further evaluation is required.

Response Time:
Response time is the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 9 percent of the corresponding final value is reached as displayed on the instrument readout meter.

Performance Requirement: Section 3.1.2(b) of Method 21 requires the instrument response time to be equal to or less than 30 seconds.

Evaluation Frequency: Prior to placing instrument into service (for the first time or after it was out of service for maintenance or repair). If modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required prior to further use.

Evaluation Procedure: (Section 4.4.3 of Method 21) Calibrate instrument with the methane calibration gas. Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. Measure the time from switching to when 90 percent of the final stable reading is attained. Perform this test sequence three time and record the results. Calculate the average response time. Use the form below or a similar format to document this procedure.

Date: ____________________________
Operator Name: ____________________________
Facility: ____________________________
Instrument ID: ____________________________
Calibration Gas Conc.: ____________________________
90% of Calib. Gas Conc.: ____________________________

Trial No.	Time to reach 90% gas value
1	_________________seconds
2	_________________seconds
3	_________________seconds
Average	_________________seconds

Table A - 1
Monitoring Instrument Performance Evaluation
Surface Monitoring Design Plan
(cont.)

Calibration Precision:

Calibration precision is the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

Performance Requirement: The calibration precision must be equal to or less than 10 percent of the calibration gas value.

Evaluation Frequency: Must be completed prior to placing instrument into service, and at subsequent 3-month intervals or at the next use whichever is later.

Evaluation Procedure: (Section 4.4.2 of Method 21) Calibrate instrument with the methane calibration gas. Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

Date: ____________________________
Operator Name: ____________________________
Facility: ___________________________
Instrument ID: ____________________________
Calibration Gas Conc.: ____________________________

Trial No.	Meter Reading After Zero Gas	Difference Between Calibration Gas and Meter Reading
1	________________ppm	______________ppm
2	________________ppm	______________ppm
3	________________ppm	______________ppm
	Average Difference:	______________ppm

Calibration Precision = Average Difference/Calibration Gas Conc. X 100%
= _______________ / _________________ X 100%
= _________%

Table A - 2
Instrument Calibration and Monitoring Procedures
Surface Monitoring Design Plan

The calibration procedures in section 4.2 of 40 CFR 60 Appendix A, Method 21 must be conducted immediately before commencing a surface monitoring survey. [40 CFR 60.755(d)(4)] Calibration, background readings and monitoring details can be recorded using this form.

Calibration Procedure:
The calibration gas should be methane in air at a nominal concentration of 500 ppm. [See section 3.2 of Method 21 for further calibration gas requirements.]

Assemble and start up the analyzer according to the manufacturer's instructions. After the appropriate warm-up period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value. Record the calibration information in the table below.

Background Concentration:
Determine the background concentration by moving the probe inlet upwind outside the boundary of the landfill at a distance of at least 30 meters from the perimeter wells. Record the background concentration and location in the table below.

General Information:
Date: ____________________________
Operator Name: ____________________________
Facility: ____________________________
Instrument ID: ____________________________
Wind Direction: N NE E SE S SW W NW (circle one)
Approximate Wind Speed_______________________mph
General Weather: ______ ^{o}F,
clear, partly cloudy, overcast, _______________ (circle one or write in)
no precip., drizzle, rain, snow, ______________ (circle one or write in)

Calibration Information:
Calibration Gas Conc.: __________ppm
Conduct internal zero calibration? Yes No (circle one)
Instrument reading after calibration: __________ppm (should be same as above)
Time of Calibration: ___:___ am pm (fill in and pick one)

Background Concentration Information:
Background concentration upwind of site: ____________ppm
Background concentrations downwind of site: ____________ppm

Location of background readings:____

Average of background readings: ____________ppm
New Leak Definition (500 ppm + above average): ____________ppm

APPENDIX A
40 CFR 60 Appendix A, Method 21

1.0 Scope and Application

1.1 Analytes.

Analyte	CAS No.
Volatile Organic Compounds (VOC)..........	No CAS number assigned.

1.2 Scope. This method is applicable for the determination of VOC leaks from process equipment. These sources include, but are not limited to, valves, flanges and other connections, pumps and compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals.

1.3 Data Quality Objectives. Adherence to the requirements of this method will enhance the quality of the data obtained from air pollutant sampling methods.

2.0 Summary of Method

2.1 A portable instrument is used to detect VOC leaks from individual sources. The instrument detector type is not specified, but it must meet the specifications and performance criteria contained in Section 6.0. A leak definition concentration based on a reference compound is specified in each applicable regulation. This method is intended to locate and classify leaks only, and is not to be used as a direct measure of mass emission rate from individual sources.

3.0 Definitions

3.1 *Calibration gas* means the VOC compound used to adjust the instrument meter reading to a known value. The calibration gas is usually the reference compound at a known concentration approximately equal to the leak definition concentration.

3.2 *Calibration precision* means the degree of agreement between measurements of the same known value, expressed as the relative percentage of the average difference between the meter readings and the known concentration to the known concentration.

3.3 *Leak definition concentration* means the local VOC concentration at the surface of a leak source that indicates that a VOC emission (leak) is present. The leak definition is an instrument meter reading based on a reference compound.

3.4 *No detectable emission* means a local VOC concentration at the surface of a leak source, adjusted for local VOC ambient concentration, that is less than 2.5 percent of the specified leak definition concentration. that indicates that a VOC emission (leak) is not present.

3.5 *Reference compound* means the VOC species selected as the instrument calibration basis for specification of the leak definition concentration. (For example, if a leak definition concentration is 10,000 ppm as methane, then any source emission that results in a local concentration that yields a meter reading of 10,000 on an instrument meter calibrated with methane would be classified as a leak. In this example, the leak definition concentration is 10,000 ppm and the reference compound is methane.)

3.6 *Response factor* means the ratio of the known concentration of a VOC compound to the observed meter reading when measured using an instrument calibrated with the reference compound specified in the applicable regulation.

3.7 *Response time* means the time interval from a step change in VOC concentration at the input of the sampling system to the time at which 90 percent of the corresponding final value is reached as displayed on the instrument readout meter.

4.0 Interferences [Reserved]

5.0 Safety

5.1 Disclaimer. This method may involve hazardous materials, operations, and equipment. This test method may not address all of the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to performing this test method.

5.2 Hazardous Pollutants. Several of the compounds, leaks of which may be determined by this method, may be irritating or corrosive to tissues (*e.g.,* heptane) or may be toxic (*e.g.,* benzene, methyl alcohol). Nearly all are fire hazards. Compounds in emissions should be determined through familiarity with the source. Appropriate precautions can be found in reference documents, such as reference No. 4 in Section 16.0.

6.0 Equipment and Supplies

A VOC monitoring instrument meeting the following specifications is required:

6.1 The VOC instrument detector shall respond to the compounds being processed. Detector types that may meet this requirement include, but are not limited to, catalytic oxidation, flame ionization, infrared absorption, and photoionization.

6.2 The instrument shall be capable of measuring the leak definition concentration specified in the regulation.

6.3 The scale of the instrument meter shall be readable to ±2.5 percent of the specified leak definition concentration.

6.4 The instrument shall be equipped with an electrically driven pump to ensure that a sample is provided to the detector at a constant flow rate. The nominal sample flow rate, as measured at the sample probe tip, shall be 0.10 to 3.0 l/min (0.004 to 0.1 ft^3 /min) when the probe is fitted with a glass wool plug or filter that may be used to prevent plugging of the instrument.

6.5 The instrument shall be equipped with a probe or probe extension or sampling not to exceed 6.4 mm (1/4 in) in outside diameter, with a single end opening for admission of sample.

6.6 The instrument shall be intrinsically safe for operation in explosive atmospheres as defined by the National Electrical Code by the National Fire Prevention Association or other applicable regulatory code for operation in any explosive atmospheres that may be encountered in its use. The instrument shall, at a minimum, be intrinsically safe for Class 1, Division 1 conditions, and/or Class 2, Division 1 conditions, as appropriate, as defined by the example code. The instrument shall not be operated with any safety device, such as an exhaust flame arrestor, removed.

7.0 Reagents and Standards

7.1 Two gas mixtures are required for instrument calibration and performance evaluation:

7.1.1 Zero Gas. Air, less than 10 parts per million by volume (ppmv) VOC.

7.1.2 Calibration Gas. For each organic species that is to be measured during individual source surveys, obtain or prepare a known standard in air at a concentration approximately equal to the applicable leak definition specified in the regulation.

7.2 Cylinder Gases. If cylinder calibration gas mixtures are used, they must be analyzed and certified by the manufacturer to be within 2 percent accuracy, and a shelf life must be specified. Cylinder standards must be either reanalyzed or replaced at the end of the specified shelf life.

7.3 Prepared Gases. Calibration gases may be prepared by the user according to any accepted gaseous preparation procedure that will yield a mixture accurate to within 2 percent. Prepared standards must be replaced each day of use unless it is demonstrated that degradation does not occur during storage.

7.4 Mixtures with non-Reference Compound Gases. Calibrations may be performed using a compound other than the reference compound. In this case, a conversion factor must be determined for the alternative compound such that the resulting meter readings during source surveys can be converted to reference compound results.

8.0 Sample Collection, Preservation, Storage, and Transport

8.1 Instrument Performance Evaluation. Assemble and start up the instrument according to the manufacturer's instructions for recommended warmup period and preliminary adjustments.

8.1.1 Response Factor. A response factor must be determined for each compound that is to be measured, either by testing or from reference sources. The response factor tests are required before placing the analyzer into service, but do not have to be repeated at subsequent intervals.

8.1.1.1 Calibrate the instrument with the reference compound as specified in the applicable regulation. Introduce the calibration gas mixture to the analyzer and record the observed meter reading. Introduce zero gas until a stable reading is obtained. Make a total of three measurements by alternating between the calibration gas and zero gas. Calculate the response factor for each repetition and the average response factor.

8.1.1.2 The instrument response factors for each of the individual VOC to be measured shall be less than 10 unless otherwise specified in the applicable regulation. When no instrument is available that meets this specification when calibrated with the reference VOC specified in the applicable regulation, the available instrument may be calibrated with one of the VOC to be measured, or any other VOC, so long as the instrument then has a response factor of less than 10 for each of the individual VOC to be measured.

8.1.1.3 Alternatively, if response factors have been published for the compounds of interest for the instrument or detector type, the response factor determination is not required, and existing results may be referenced. Examples of published response factors for flame ionization and catalytic oxidation detectors are included in References 1–3 of Section 17.0.

8.1.2 Calibration Precision. The calibration precision test must be completed prior to placing the analyzer into service and at subsequent 3-month intervals or at the next use, whichever is later.

8.1.2.1 Make a total of three measurements by alternately using zero gas and the specified calibration gas. Record the meter readings. Calculate the average algebraic difference between the meter readings and the known value. Divide this average difference by the known calibration value and multiply by 100 to express the resulting calibration precision as a percentage.

8.1.2.2 The calibration precision shall be equal to or less than 10 percent of the calibration gas value.

8.1.3 Response Time. The response time test is required before placing the instrument into service. If a modification to the sample pumping system or flow configuration is made that would change the response time, a new test is required before further use.

8.1.3.1 Introduce zero gas into the instrument sample probe. When the meter reading has stabilized, switch quickly to the specified calibration gas. After switching, measure the time required to attain 90 percent of the final stable reading. Perform this test sequence three times and record the results. Calculate the average response time.

8.1.3.2 The instrument response time shall be equal to or less than 30 seconds. The instrument pump, dilution probe (if any), sample probe, and probe filter that will be used during testing shall all be in place during the response time determination.

8.2 Instrument Calibration. Calibrate the VOC monitoring instrument according to Section 10.0.

8.3 Individual Source Surveys.

8.3.1 Type I—Leak Definition Based on Concentration. Place the probe inlet at the surface of the component interface where leakage could occur. Move the probe along the interface periphery while observing the instrument readout. If an increased meter reading is observed, slowly sample the interface where leakage is indicated until the maximum meter reading is obtained. Leave the probe inlet at this maximum reading location for approximately two times the instrument response time. If the maximum observed meter reading is greater than the leak definition in the applicable regulation, record and report the results as specified in the regulation reporting requirements. Examples of the application of this general technique to specific equipment types are:

8.3.1.1 Valves. The most common source of leaks from valves is the seal between the stem and housing. Place the probe at the interface where the stem exits the packing gland and sample the stem circumference. Also, place the probe at the interface of the packing gland take-up flange seat and sample the periphery. In addition, survey valve housings of multipart assembly at the surface of all interfaces where a leak could occur.

8.3.1.2 Flanges and Other Connections. For welded flanges, place the probe at the outer edge of the flange-gasket interface and sample the circumference of the flange. Sample other types of nonpermanent joints (such as threaded connections) with a similar traverse.

8.3.1.3 Pumps and Compressors. Conduct a circumferential traverse at the outer surface of the pump or compressor shaft and seal interface. If the source is a rotating shaft, position the probe inlet within 1 cm of the shaft-seal interface for the survey. If the housing configuration prevents a complete traverse of the shaft periphery, sample all accessible portions. Sample all other joints on the pump or compressor housing where leakage could occur.

8.3.1.4 Pressure Relief Devices. The configuration of most pressure relief devices prevents sampling at the sealing seat interface. For those devices equipped with an enclosed extension, or horn, place the probe inlet at approximately the center of the exhaust area to the atmosphere.

8.3.1.5 Process Drains. For open drains, place the probe inlet at approximately the center of the area open to the atmosphere. For covered drains, place the probe at the surface of the cover interface and conduct a peripheral traverse.

8.3.1.6 Open-ended Lines or Valves. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.7 Seal System Degassing Vents and Accumulator Vents. Place the probe inlet at approximately the center of the opening to the atmosphere.

8.3.1.8 Access door seals. Place the probe inlet at the surface of the door seal interface and conduct a peripheral traverse.

8.3.2 Type II—“No Detectable Emission”. Determine the local ambient VOC concentration around the source by moving the probe randomly upwind and downwind at a distance of one to two meters from the source. If an interference exists with this determination due to a nearby emission or leak, the local ambient concentration may be determined at distances closer to the source, but in no case shall the distance be less than 25 centimeters. Then move the probe inlet to the surface of the source and determine the concentration as outlined in Section 8.3.1. The difference between these concentrations determines whether there are no detectable emissions. Record and report the results as specified by the regulation. For those cases where the regulation requires a specific device installation, or that specified vents be ducted or piped to a control device, the existence of these conditions shall be visually confirmed. When the regulation also requires that no detectable emissions exist, visual observations and sampling surveys are required. Examples of this technique are:

8.3.2.1 Pump or Compressor Seals. If applicable, determine the type of shaft seal. Perform a survey of the local area ambient VOC concentration and determine if detectable emissions exist as described in Section 8.3.2.

8.3.2.2 Seal System Degassing Vents, Accumulator Vessel Vents, Pressure Relief Devices. If applicable, observe whether or not the applicable ducting or piping exists. Also, determine if any sources exist in the ducting or piping where emissions could occur upstream of the control device. If the required ducting or piping exists and there are no sources where the emissions could be vented to the atmosphere upstream of the control device, then it is presumed that no detectable emissions are present. If there are sources in the ducting or piping where emissions could be vented or sources where leaks could occur, the sampling surveys described in Section 8.3.2 shall be used to determine if detectable emissions exist.

8.3.3 Alternative Screening Procedure.

8.3.3.1 A screening procedure based on the formation of bubbles in a soap solution that is sprayed on a potential leak source may be used for those sources that do not have continuously moving parts, that do not have surface temperatures greater than the boiling point or less than the freezing point of the soap solution, that do not have open areas to the atmosphere that the soap solution cannot bridge, or that do not exhibit evidence of liquid leakage. Sources that have these conditions present must be surveyed using the instrument technique of Section 8.3.1 or 8.3.2.

8.3.3.2 Spray a soap solution over all potential leak sources. The soap solution may be a commercially available leak detection solution or may be prepared using concentrated detergent and water. A pressure sprayer or squeeze bottle may be used to dispense the solution. Observe the potential leak sites to determine if any bubbles are formed. If no bubbles are observed, the source is presumed to have no detectable emissions or leaks as applicable. If any bubbles are observed, the instrument techniques of Section 8.3.1 or 8.3.2 shall be used to determine if a leak exists, or if the source has detectable emissions, as applicable.

9.0 Quality Control

Section	Quality control measure	Effect
8.1.2........................	Instrument calibration precision check.	Ensure precision and accuracy, respectively, of instrument response to standard.
10.0.........................	Instrument calibration.	

10.0 Calibration and Standardization

10.1 Calibrate the VOC monitoring instrument as follows. After the appropriate warmup period and zero internal calibration procedure, introduce the calibration gas into the instrument sample probe. Adjust the instrument meter readout to correspond to the calibration gas value.

Note: If the meter readout cannot be adjusted to the proper value, a malfunction of the analyzer is indicated and corrective actions are necessary before use.

11.0 Analytical Procedures [Reserved]

12.0 Data Analyses and Calculations [Reserved]

13.0 Method Performance [Reserved]

14.0 Pollution Prevention [Reserved]

15.0 Waste Management [Reserved]

16.0 References

1. Dubose, D.A., and G.E. Harris. Response Factors of VOC Analyzers at a Meter Reading of 10,000 ppmv for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2–81051. September 1981.

2. Brown, G.E., *et al.* Response Factors of VOC Analyzers Calibrated with Methane for Selected Organic Compounds. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2–81–022. May 1981.

3. DuBose, D.A. *et al.* Response of Portable VOC Analyzers to Chemical Mixtures. U.S. Environmental Protection Agency, Research Triangle Park, NC. Publication No. EPA 600/2–81–110. September 1981.

4. Handbook of Hazardous Materials: Fire, Safety, Health. Alliance of American Insurers. Schaumberg, IL. 1983.

Appendix E

APPENDIX E

APPROVED USEPA ALTERNATE MONITORING PROCEDURES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

APR 04 2008

REPLY TO THE ATTENTION OF:

(AE-17J)

Laura L. Niemann, P.E.
Project Engineer
Environmental Information Logistics, LLC
130 E. Main Street
Caledonia, Michigan 49316

Re: Veolia Environmental Services—Zion Landfill

Dear Ms. Niemann:

Thank you for your February 29, 2008 and April 3, 2008 letters to the U. S. Environmental Protection Agency, requesting adjusted standards for pressure and oxygen for six permanent and interim gas extraction locations at the Veolia Environmental Services—Zion Landfill (VES-Zion Landfill), located in Zion, Illinois. VES-Zion is subject to the New Source Performance Standards ("NSPS") for Municipal Solid Waste Landfills ("40 CFR Part 60, Subpart WWW" or the "Landfill NSPS"). The regulation at 40 CFR § 60.753(b) requires the owner or operator to operate the collection system with negative pressure at each wellhead except under certain situations, one being a decommissioned well. 40 CFR § 60.753(c) requires the owner or operator to operate each interior wellhead in the collection system with a landfill gas temperature of less than 131 degrees Fahrenheit and with either a nitrogen level less than 20 percent or an oxygen level less than 5 percent. The owner or operator may establish a higher temperature, nitrogen or oxygen value at a particular well.

VES-Zion's request for approval of alternate standards for pressure and oxygen pertains to extraction locations where gas flows are so low that applying even minimal vacuum results in air infiltration that causes exceedances of the applicable oxygen concentration limit. Shutting down such wells will prevent the air infiltration that leads to the oxygen exceedances, but shutting down a well may cause positive pressure in the wellhead as landfill gas builds up. Therefore, simultaneously complying with both the pressure and oxygen concentration limits in 40 CFR § 60.753 can be difficult for wells where gas flow rates are low.

The extraction locations that VES-Zion wants covered by these alternative standards and procedures are extraction locations: EW01, EW12A, EW164, CEW1W, CEW5, and CEW5E:

EW01 is a vertical gas extraction well located in one of the oldest areas of the landfill where gas flow rates have been steadily declining. However, since the well will occasionally show decent gas quality, VES-Zion does not want to decommission the well.

EW12A is another vertical gas extraction well located in the same area as EW01 but EW12A is shallow and located at the edge of waste. The facility does not want to decommission this well since it is useful for controlling subsurface migration.

EW164 is a vertical gas extraction well installed in a newer area of waste. Since the waste is still fairly young, gas production is not yet firmly established. It is likely when gas production is well underway that alternate standards/procedures will no longer be required.

CEW1W, CEW5 and CEW5E are leachate cleanout risers. Because of the design of these systems, there is often air intrusion. In addition, if the leachate pipe perforations are submerged with leachate, very little landfill gas can enter the piping for collection. The site does not want to disconnect the cleanout risers from the gas control system since they periodically do contain large quantities of gas and are a key tool for odor control.

According to VES-Zion, the persistent exceedances of oxygen and pressure at the above extraction locations are not due to operational or maintenance issues but are the result of declining gas quality and flow rates. Instead of decommissioning or permanently disconnecting such extraction locations, which would result in no gas control, VES-Zion wants to keep operating them and allow the locations to remain shut off, under positive pressure, with monthly monitoring and periodic adjustment to vacuum to remove accumulated landfill gas.

EPA's Determination

EPA agrees and has already determined that the procedures outlined below have the potential to lower overall non-methane organic compound (NMOC) emissions from the extraction points in comparison to decommissioning. The potential increase in NMOC control system efficiency stems from the ability of the facility to quickly resume gas collection if there are improvements in gas quality or increases in the gas production rate at the extraction points. If extraction locations in a nonproductive area are only intermittently shut off as opposed to decommissioned (physically disconnected from the collection and control system), there is greater NMOC emission control.

Therefore, EPA approves the below described alternate procedures for extraction points EW01, EW12A, EW164, CEW1W, CEW5, and CEW5E. These procedures are generally the same as those proposed by VES-Zion, except for additional reporting requirements and a requirement that the alternate procedures be terminated if gas quality improvements can be maintained.

1. When the oxygen concentration at the extraction location does not decline to acceptable levels after more than one hour of reduced vacuum, the location may be shut off until the gas quality recovers.

2. The monthly monitoring required by 40 CFR Part 60, Subpart WWW will be conducted for these locations, but positive pressure or elevated oxygen concentrations will not be considered as exceedances of the operating limits in 40 CFR § 60.753. However, the monthly monitoring results must be reported to the Illinois Environmental Protection Agency ("IEPA"). The reports to IEPA shall note if and when the extraction points are shut off in accordance with this letter.

3. If monthly monitoring indicates that pressure has built up in the extraction point and the oxygen concentration still exceeds 5 percent, the location will be briefly opened to relieve the pressure and may then be shut down until it is monitored the following month.

4. The surface monitoring required by 40 CFR Part 60, Subpart WWW will continue to be conducted in this area. Standard remediation steps, including evaluating the need to return the extraction location to full-time service, must be followed if exceedances of the 500 ppm methane surface concentration limits are detected in the immediate vicinity.

5. If the monthly monitoring indicates that gas quality has improved (i.e., the oxygen concentration has dropped below 5 percent), the extraction location will be brought back on line until the gas quality declines again. If the oxygen levels can be maintained below the regulatory limit of 5 percent, this alternate operating procedure is terminated and the well shall be operated in accordance with the regulatory requirements.

In addition, you should submit this information to IEPA as part of a design plan change. IEPA must be made aware that the above six extraction points are low gas-producing wells and that they are subject to alternative limits/procedures. IEPA will periodically review the wells' status to ensure that if higher gas quality can be maintained, this alternate operating procedure should be terminated and the extraction points shall be operated in accordance with the regulatory requirements.

This response has been coordinated with Yasmine Keppner of IEPA. If you have any questions regarding this letter, feel free to contact Linda H. Rosen, of my staff, at (312) 886-6810.

Sincerely yours,

George T. Czerniak, Chief
Air Enforcement and Compliance Assurance Branch

cc: Ray Pilapil, Manager
Bureau of Air – Compliance and Enforcement Section
Illinois Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

OCT 03 2008

REPLY TO THE ATTENTION OF:

(AE-17J)

Mr. James A. Lewis
General Manager
Veolia ES Zion Landfill, Inc.
701 Green Bay Road
Zion, Illinois 60099

Re: Veolia Environmental Services—Zion Landfill

Dear Mr. Lewis:

Thank you for your August 20, 2008 letter and September 10, 2008 facsimile to the U. S. Environmental Protection Agency, requesting adjusted standards for pressure and oxygen at five gas extraction locations at the Veolia Environmental Services—Zion Landfill (VES-Zion), located in Zion, Illinois. Your letter also requests an alternative compliance timeline for well EW-10 at VES-Zion which measured an oxygen exceedance on August 7, 2008. VES-Zion is subject to the New Source Performance Standards ("NSPS") for Municipal Solid Waste Landfills ("40 CFR Part 60, Subpart WWW" or the "Landfill NSPS").

Request for Adjusted Pressure/Oxygen Standards

The regulation at 40 CFR § 60.753(b) requires the owner or operator to operate the collection system with negative pressure at each wellhead except under certain situations, one being a decommissioned well. 40 CFR § 60.753(c) requires the owner or operator to operate each interior wellhead in the collection system with a landfill gas temperature of less than 131 degrees Fahrenheit and with either a nitrogen level less than 20 percent or an oxygen level less than 5 percent. The owner or operator may establish a higher temperature, nitrogen or oxygen value at a particular well. The extraction locations that VES-Zion wants covered by alternative standards and procedures for pressure/oxygen are extraction locations: LRC4 and LRC5; EW02; and EW-21 and EW-23.

LRC4 and LRC5 are horizontal trenches used for gas collection. According to the facility, these trenches experience greater disruptions to gas collection due to landfill settlement than traditional vertical gas extraction wells. If the trenches get watered in, the facility is unable to install a pump to remove liquids as the landfill can with vertical gas extraction wells. However, since some gas is being collected from the LRC4 and LRC5 trenches and there are few permanent vertical wells installed nearby, the facility wishes to keep these locations in the NSPS collection network at this time.

EW-02 is a vertical gas extraction well located in one of the oldest areas of the landfill. Some of the waste is more than 30 years old and gas flow rates have been steadily declining. There is little refuse available to collect gas from.

EW-21 and EW-22 are vertical gas extraction wells which are located in the very old part of the landfill. These wells are very shallow and are located at the edge of the waste. Landfill gas from this area has been declining for a number of years.

EPA's Determination on Adjusted Pressure/Oxygen Standards Request

EPA will not approve alternative standards for pressure or oxygen for horizontal trenches LRC4 and LRC5. The reason these extraction points are not meeting the operational standards of the NSPS does not appear to be related to low gas production or low gas quality inherent in the waste. Rather, the operational problems for these wells seem to be the result of landfill settlement and/or buildup of water that impedes gas collection. It also appears that there may not be enough vertical gas extraction wells in this area of the landfill because your letter states that "few" permanent vertical wells are installed nearby. You should either fix these trenches, which appear to be ineffective in collecting gas, and/or consider installing additional wells in the area to collect gas. In any event, the requirements of 40 CFR § 60.759(a) and the NSPS must be met and all design plan changes must be approved by the Illinois EPA.

Regarding wells EW-02, EW-21 and EW-23, the information submitted by VES-Zion indicates that the exceedances of oxygen and pressure at these wells are not due to operational or maintenance issues but are the result of declining gas quality and gas production in an area of older waste. The gas production and gas quality appear to be so low that applying even minimal vacuum can result in air infiltration that causes exceedances of the applicable oxygen concentration limit. Shutting down such wells will prevent the air infiltration that leads to the oxygen exceedances, but shutting down a well may cause positive pressure in the wellhead as landfill gas builds up. Therefore, simultaneously complying with both the pressure and oxygen concentration limits in 40 CFR § 60.753 can be difficult for such wells. Instead of decommissioning or permanently disconnecting such wells, which would result in no gas control, VES-Zion wants to keep operating them and allow the locations to remain shut off, under positive pressure, with monthly monitoring and periodic adjustment to vacuum to remove accumulated landfill gas.

EPA agrees and has already determined that the procedures outlined below have the potential to lower overall non-methane organic compound ("NMOC") emissions (in comparison to decommissioning) at gas wells with declining gas production and gas quality. The potential increase in NMOC control system efficiency stems from the ability of the facility to quickly resume gas collection if there are improvements in gas quality or increases in the gas production rate at the wells. If wells in a nonproductive area are only intermittently shut off as opposed to decommissioned (physically disconnected from the collection and control system), there is greater NMOC emission control.

Therefore, EPA approves the below described alternate procedures for gas wells EW-02, EW-21, and EW-23:

1. When the oxygen concentration at the well does not decline to acceptable levels after more than one hour of reduced vacuum, the location may be shut off until the gas quality recovers.

2. The monthly monitoring required by 40 CFR Part 60, Subpart WWW will be conducted for these wells, but positive pressure or elevated oxygen concentrations will not be considered as exceedances of the operating limits in 40 CFR § 60.753. However, the monthly monitoring results must be reported to the Illinois Environmental Protection Agency ("IEPA"). The reports to IEPA shall note if and when the wells are shut off in accordance with this letter.

3. If monthly monitoring indicates that pressure has built up in the well and the oxygen concentration still exceeds 5 percent, the well will be briefly opened to relieve the pressure and may then be shut down until it is monitored the following month.

4. The surface monitoring required by 40 CFR Part 60, Subpart WWW will continue to be conducted in this area. Standard remediation steps, including evaluating the need to return the well to full-time service, must be followed if exceedances of the 500 ppm methane surface concentration limits are detected in the immediate vicinity.

5. If the monthly monitoring indicates that gas quality has improved (i.e., the oxygen concentration has dropped below 5 percent), the well will be brought back on line until the gas quality declines again. If the oxygen levels can be maintained below the regulatory limit of 5 percent, this alternate operating procedure is terminated and the well shall be operated in accordance with the regulatory requirements.

Finally, you should submit this information to IEPA as part of a design plan change. IEPA must be made aware that the above three wells are low gas-producing, low gas quality wells and that they are subject to alternative limits/procedures. IEPA will periodically review the wells' status to ensure that if higher gas quality can be maintained, this alternate operating procedure should be terminated and the wells be operated in accordance with the regulatory requirements.

Request for Alternative Compliance Timeline

VES-Zion is requesting an alternative timeline to correct an oxygen exceedance at well EW-10. The NSPS sets forth compliance provisions for gas collection and control systems under 40 CFR § 60.755. The regulation at 40 CFR § 60.755(a)(5) states: "For the purpose of identifying whether excess air infiltration into the landfill is occurring, the owner or operator shall monitor each well monthly for temperature and nitrogen or oxygen as provided in § 60.753(c). If a well exceeds one of these operating parameters, action shall be initiated to correct the exceedance within 5 calendar days. If correction of the exceedance cannot be achieved within 15 calendar days of the first measurement, the gas collection system shall be expanded to correct the exceedance within 120 days of the initial exceedance. Any attempted corrective measure shall not cause exceedances of other operational or performance standards. An alternative timeline for correcting the exceedance may be submitted to the Administrator for approval."

On August 7, 2008, an oxygen reading of 8.3 percent was measured at well EW-10. Upon inspection, the well was found to have a faulty de-watering pump resulting in a watered out well with virtually no gas flow. Well EW-10 has also been impacted by liquids impeding gas movement through the slotted portion of the well encasement, therefore decreasing gas extraction efficiency and flow. The site plans to remove and repair the pump in the next few weeks, but it may take several additional weeks to remove enough liquids to allow normal gas flow to resume within the well. VES-Zion requests an alternative compliance timeline of 120 days, until December 5, 2008, to allow sufficient time for the oxygen exceedance to be corrected.

EPA is approving an alternative timeline for VES-Zion Landfill's Well EW-10 of 90 days from the date of the initial exceedance, or until November 5, 2008. EPA believes this is a sufficient amount of time for VES-Zion to correct this problem and still have additional time to expand the gas collection system if the oxygen standard cannot be met by November 5. If VES-Zion cannot achieve an oxygen concentration below 5% by November 5, 2008, then per 40 CFR § 60.755(a)(5), VES-Zion must expand the gas collection system within 120 days of the initial exceedance.

If you have any questions regarding this letter, feel free to contact Linda H. Rosen, of my staff, at (312) 886-6810.

Sincerely yours,

George T. Czerniak
Chief
Air Enforcement and Compliance Assurance Branch

cc: Ray Pilapil, Manager
Bureau of Air – Compliance and Enforcement Section
Illinois Environmental Protection Agency

Yasmine Keppner
Bureau of Air-Compliance and Enforcement Section
Illinois Environmental Protection Agency